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Baltimore & Ohio Railroad Company,

OFFICE OF THE PRESIDENT.

SERVICE

REPORT ON TECHNICAL EDUCATION,

WITH SPECIAL REFERENCE

TO THE

Baltimore & Ohio Railroad Service.

BY

DR. W. T. BARNARD,

ASSISTANT TO THE PRESIDENT.

OCTOBER 1st, 1886.

BALTIMORE:
PRESS OF ISAAC FRIEDENWALD,
1887.

NOTE TO THE READER

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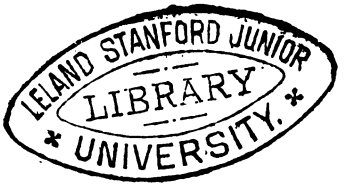

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"The time is not far distant when science and manipulative skill must be joined together."—HUMBOLDT.

"Whatever we wish to see introduced into the life of a nation must first be introduced into our schools."—HUMBOLDT.

"What we need in this country is a CORRECT PUBLIC OPINION *on the relation of education to industry."*—JUDGE MCARTHUR.

"No scheme of technical education is likely to be seriously entertained which will delay the entrance of boys into working life or prevent them from contributing to their own support as early as they do at present."—HUXLEY.

PREFACE.

The solicitations of several prominent citizens of Baltimore, earnestly interested in its welfare, and of other friends specially concerned in the development of our American railroad system, who, after examining the manuscript of this report, believed that the data therein contained would materially and beneficially affect the educational work of Baltimore and of our railways generally, have determined me to give these pages a wider circulation than merely among the officials of the Baltimore and Ohio Railroad Company, for whose information they were primarily written.

In doing this I should much prefer re-arranging this data, so that the publication might show no relation whatever to the Baltimore and Ohio Railroad Company, but other demands upon my time prevent this revision. Though, for this reason, material collected for my own purposes and deductions therefrom are embodied in an official report, it is to be distinctly understood that no one but the writer stands committed to the statements or views therein contained; the responsibility for which he, as a private citizen, solely accepts.

W. T. BARNARD.

BALTIMORE AND OHIO RAILROAD COMPANY.

Service Report on Technical Education,

WITH

SPECIAL REFERENCE TO BALTIMORE & OHIO R. R. SERVICE.

Baltimore, October 1st, 1886.

MR. ROBERT GARRETT,
President Baltimore & Ohio Railroad Company.

SIR:—

June 7th, 1881, the General Counsel of the Baltimore & Ohio Railroad Company invited your attention to a scholarly and thoughtful address on technical education, delivered before the Maryland Institute, June 4th, by Hon. S. Teackle Wallis, and, referring especially to so much thereof as related to the establishment in Baltimore of a technical school for scientific and mechanical instruction, Mr. Cowen said:

General Counsel Cowen recommends the establishment of a technical school for scientific and mechanical instruction of B. & O. employes.

"I have always thought that the Baltimore & Ohio Railroad Company did not have enough of educated talent in its service, and that, among its artisans and mechanics, there should be more scientific knowledge than can now be found in our various departments.

"It strikes me that there is no one in the city so much interested in the establishment of such a school as Mr. Wallis indicates in connection with the Maryland Institute as the Baltimore & Ohio Railroad Company.

"I presume you have a hundred or more apprentices at Mount Clare, and have thousands of artisans along your entire road, who should have received a first-class education at some technological school, who have never received any such education at any place of instruction, and have simply an empirical knowledge gained from practical work.

"As Mr. Wallis justly says, the 'practical man,' so called, has had his day, and is fast going to the wall under the law of the 'survival of the fittest.'

"On all mechanical subjects there is an amount of learning which can be obtained from schools, and cannot be obtained in any other way, and beyond question the Railroad Company should endeavor to avail itself of the class of men who have had this early training.

"There is no way in which this could be so well done as by having a competent technological school in the city, the students of which could be taken into our service from time to time, and would certainly elevate it very much by the application of the learning derived from skilled instructors.

"I wish you would look at the subject, both as an officer and a citizen, and see whether there is any way in which you can aid in the establishment of such a place of instruction for the deserving artisans and mechanics of the city."

No record of earlier consideration of technical education for B. & O. employes.

A careful search amongst the voluminous records of this Company fails to show that the necessity for a higher standard of qualifications for its operatives had, before this communication, found official expression, even if it had engaged the attention of the Company's officers. Indeed, technical education in mechanic arts had then but slightly attracted public attention in this country, except locally and as the result of endowed institutions for combined scientific and manual training, such as the schools at Worcester, Troy, Boston, Hoboken, *et al.;* this notwithstanding the fact that, as early as July 2d, 1862, Congress—contemplating especially the promotion of practical education of the producing classes—had made liberal grants of land to the several States in aid of the establishment of schools for scientific instruction in agriculture and mechanical pursuits.

Scientific instruction in mechanic arts in its infancy in U. S.

Technical training provided for by Congress in 1862.

Some time subsequently you requested me to make this subject—thus forcibly brought to your notice—one of special investigation and recommendation. My time being then wholly occupied in organizing the Relief Association, I was not able, at the moment, to give it more than cursory and casual consideration, except as to some special points upon which reports were, from time to time, rendered—*e. g.*, upon the necessity for a laboratory for testing raw and manufactured materials used in construction, and for experimental work in engineering and in mechanical physics—resulting in the establishment of the chemical and physical laboratory at Mt. Clare. Meanwhile our present Vice-President, Mr. Samuel Spencer, having been assigned to the direction of the

Vice-Pres't Garrett calls for special investigation and report upon the practicability of technically educating R. R. employes.

Establishment of a chemical and physical laboratory at Mt. Clare.

physical operations of the service, was enabled to correct many (and to favorably influence other) practices which were operating detrimentally to the Company's interests; so that there seemed to be no special urgency for this report.

Since retiring from the executive management of the Relief Association I have, as press of other engagements permitted, given the subject of technical education IN ITS RELATION TO RAILWAY SERVICE "*the special investigation and study*" you requested, and herewith submit, as briefly as its importance permits, the results of my labors.

Also, at an earlier date, taking advantage of the erection of a new passenger-car shop at Mt. Clare, I recommended that sufficient space be included in its outbuildings to serve temporarily as class-rooms for the theoretical instruction of apprentices, and, having been so provided, those rooms are now utilized for the Employes' Circulating Library, and for instructing classes of apprentices in accordance with the program announced in your Executive Order No. 6, of January 15th, 1885, hereto appended [Exhibit A], which was designed to be initiatory of the plan of instruction recommended in this report.

Establishment of technical class instruction of apprentices at Mt. Clare.

At the threshold of an inquiry into the status of technical education at the present day, the investigator will be astonished no less at the magnitude of the subject than at the revolution it has caused in the trade relations between competing sections of the same, and between different, countries; always in favor of those utilizing its efficient aid. One has only to peruse, in the leading English and Continental newspapers and periodicals, the legislative debates, governmental, municipal and trade reports and editorials on this subject, constantly published, to realize the overshadowing importance which, in Europe, is now at-

Revolution in trade relations caused by technological education.

Interest taken in it in England, Germany, etc.

tached to technical instruction, not only by manufacturing and commercial interests directly affected by it, but perhaps to a greater degree by the foremost statesmen and political economists of the day; as witness the writings of such noted authorities as Profs. Huxley, Ayrton, Siemens, Kennedy, Solly, *et al.*, the debates in Parliament, and the attempts of Prince Bismarck, of Germany, of Lord Salisbury and other English treasury officials, to solve, through its agency, the great social problems affecting the masses of their densely populated countries.

Character of investigation into status of technical instruction.

In order to acquire such thorough knowledge of what has been, and is being, done in this field as would enable me to make intelligently the recommendations called for, it became necessary to study an extensive literature, and also, by inspection of home and foreign schools, by personal investigation among the principals and workmen of those accessible corporations and firms enforcing technical instruction of a practical character, and by witnessing their methods of applying it, to determine its economic results. In this work I was ably assisted by Messrs. C. W. Scribner and G. P. Coler, who, upon the inauguration of class instruction for apprentices, were appointed instructors at Mt. Clare. The principal schools and places visited and inspected in the performance of this duty were: Stevens Institute, Hoboken, N. J.; Massachusetts Institute of Technology, Boston, Mass.; Worcester Free Institute, Worcester, Mass.; Columbia College, N. Y.; Cooper Union, N. Y.; Philadelphia Manual Training School, Philadelphia; Spring Garden Institute, Philadelphia; Chicago Manual Training School, Chicago; Maryland Institute, Baltimore; Baltimore Manual Training School, Baltimore. Abroad, at London, the Central Institution of City and Guilds of London Institute, Finsbury College,

Institutions for technical education in America investigated.

Institutions for technical education in Europe investigated.

Young Men's Polytechnic Institute and the Birbeck Institute; at Manchester, Mather & Platt's Workshop School, Owens College and the Manchester Technical School; at Oldham, the School of Science and Art; at Leeds, Yorkshire College; at Newcastle, the Elswick School of Science, connected with the extensive works of Sir William Armstrong & Co.; at Bradford, the Bradford Technical College; at Nottingham, the University College and the People's College; at Glasgow, the College of Science and Art, Allan Glen's Institution and Anderson's College; at Edinburgh, the Science and Art Museum; at Crewe, the Science School of the London & Northwestern Railway Company; at Paris, the School of Arts and Trades; at Nuremberg, the Royal Industrial School; at Munich, the Royal Industrial School and the Polytechnic School; at Zurich, the Polytechnic School; at Mulhouse, the Trades School, the Professional School and the School for Spinners and Weavers.

It is therefore to be understood that the recommendations herein contained for the application of technical instruction to our own service are founded on careful investigation and study of technical institutions at home and abroad. Recognizing that a more forcible and conclusive presentation of such a complex subject would be secured by the citation of pertinent facts and conclusions reported by or drawn from the experience of those who, by reason of special training, study or unusual facilities of observation, are acknowledged to be competent authority on the subject, rather than by advancing personal views, I have, in the preparation of this paper, freely used parliamentary and U. S. Governmental reports, and other authoritative publications on technical instruction.

Basis on which recommendations and conclusions herein contained were reached.

Our researches—which, it will be noticed, have com-

Vital importance of technical education to general industrial and commercial interests.

passed a broad field—have so impressed me with the vital importance of technical education, not only to the B. & O. Company, but to other industrial and commercial interests of Baltimore, and the United States in general, and with the almost universal ignorance of its potency displayed by those in our community whom it would most beneficially affect, that I have deemed it a duty to collate the salient results of our labors into a form that may possibly exert a favorable influence upon other interests besides that in whose behalf those labors were undertaken. To do this effectively such a report must take a much wider range than was originally contemplated, and even then the magnitude of the subject is such that it can only be considered a *sketch;* but it is hoped its matter will compensate those interested in the subject for its length: the uninterested would not peruse a less elaborate statement.

Character and scope of this report.

For obvious reasons this report is divided into, first, a sketch of the effects of technical education in Europe; second, a review of its progress and present status in the United States; the third part will show the need of more thorough and extended technical instruction in Baltimore; the fourth, the advantages which the B. & O. Company, in common with other railway interests, would derive from a thorough system of this character; and the fifth offers a program for inaugurating systematic technical instruction in our service.

EFFECTS OF TECHNICAL INSTRUCTION IN EUROPE.

Technical education forced into prominence, in Europe, by trade competition.

In Europe the necessity of technical education for industrial laborers, felt and freely acknowledged many years ago, was forced into prominence through the increasing rivalry between manufacturers and other producers com-

peting with like articles in the same markets. In order to counterbalance the advantages some engaged in a given industry enjoyed through the possession of cheaper raw material, labor, prestige or favorable situation, their competitors of foreign—and even of the same—nationality were compelled to look to improved methods of manufacture or production for ability to hold their own, and were thus brought to realize that educated labor and technical skill were the soundest elements with which to defend themselves in trade competition, in that they promote excellence of execution, inventiveness, enterprise, and all the qualities required to successfully conduct progressive industries. Under this pressure producers and manufacturers, through their guilds and other associations, were soon able to exert an influence upon their governments which has resulted in every European nation's making greater or less provision for public industrial education; until at this time not only England, France, Germany, Austria, Switzerland, Holland and Italy, but all the minor Continental States, have their governmental schools for both elementary and higher technical instruction; and even Russia—so far behind all other nations of Europe in elementary education—has found it necessary, in order to maintain her home industries, to make quite liberal provision for the maintenance of mechanical and manufacturing schools, and has established two great Imperial technical institutes—one at St. Petersburg and the other at Moscow—which are classed as amongst the finest in Europe in point of equipment and ample means. The encouragement which that government is giving industrial education has been supplemented by the action of leading Russian railroads, which have established schools for their people at their principal works.

National technological education in Europe.

Elementary scientific education in France.

While in France will be found the best examples of what may be termed higher elementary schools, in which the children of artisans, small shopkeepers, etc., are afforded opportunities of obtaining an education which is technical in so far as their studies are specially directed towards the requirements of commerce, mechanical or manufacturing industries, and while in nearly all the modern French schools—of which that at Rheims may be taken as the best type—the laboratories for teaching practical chemistry, and the equipment of other special departments which teach the technology of the trades forming the staple industries of their respective districts, leave nothing to be desired, it is in Germany and Switzerland that the movement for industrial education has attained its highest development. In the latter country the British Royal Commissioners found the value of its technical schools—the beneficial results of which were elsewhere more or less problematical—distinctly illustrated in the marked improvement of manufactures; in the elevation of the producing classes; in the diminution of crime; in the popularization of education, and, generally, exercising a most important influence upon the nation's industries and welfare. In summarizing the results of their investigations in Germany, they remark that the conviction is universal among the German people that they can only meet the competition of their rivals in other countries by training their workmen in taste and skill, and that the prosperity of their industries will increase only in proportion as they keep up the efficiency of their schools and spread their influence among the workers themselves. In support of this conclusion, extended inquiry shows that Germany and Switzerland, especially, are filling up with technological and polytechnic schools, many of them of a very

Observations of the British Royal Commissioners on the effects of scientific training in industrial arts in Germany and Switzerland.

high standard of instruction and usefulness. The polytechnic institute at Zurich [Exhibit B] may be cited as illustrative of this class of schools, which aim to combine theoretical and applied instruction in all branches of industry where scientific knowledge and skill in applying it are desirable. So successfully has this plan been worked out at Zurich that students from all parts of the world seek admission to its institute; and, referring to it, the British Commissioners say they had opportunity of judging of the advantages which it has bestowed, not only upon Switzerland, but also upon Germany, by the number of thoroughly trained scientific men it has educated who are now holding important positions in various industrial establishments which they visited. A similar institution is that at Munich. [Exhibit C.]

Direct and indirect effects of technological schools described.

The direct and indirect effects of technological schools upon the industries of their respective countries were, immediately upon their establishment, felt to be beneficial in the highest degree. Their graduates were eagerly sought out to fill important and responsible positions in manufacturing and commercial establishments, many of which had sustained serious losses through the ignorance and consequent bad management of administrative officers; and this inquiry soon far exceeded the supply. As the result of this appreciation of, and demand for, skilled laborers and supervisors, many enterprising corporations, and even private firms, engaged in manufacturing and other industries dependent for their successful operation and development upon intelligent direction and skilled labor, individually organized scientific schools and training classes in connection with their works. Some of these private schools excel most governmental and municipal institutions of similar character in enterprise, progressiveness

Development of technological education among private firms and corporations.

and immediate practical results. The conductors of many of them claim that the best results are obtained where intimate relationship between the school and the actual workshop is maintained, thereby facilitating the adaptation of theoretical training to the needs of the pupils and the character of the work on which they are engaged. As illustrative of this method of combining practical and theoretical education, I cite the schools in successful operation at the mammoth works of Sir William Armstrong at Elswick; at the great works of the London and Northwestern Railway Company at Crewe (where more than 9000 men are employed and 600 apprentices and young journeymen attend the evening classes); and that at the works of Messrs. Mather & Platt, extensive iron manufacturers at Manchester. These are but examples of a large class of schools conducted in connection with manufacturing establishments which follow this system of education, and it is reported that a large additional number of corporations and firms, encouraged by the increased profits realized by those who have adopted it, are arranging to inaugurate similar instruction at their works.

Testimony as to what technological education has accomplished.

As the foregoing statements may contain somewhat startling propositions to those who have given the subject slight consideration only, it may be well to cite from authentic testimony as to what technical education *has* accomplished.

At Crefeld, Prussia, for its silk industry.

Crefeld, Prussia, a city of about 80,000 inhabitants, relies almost entirely upon the silk industry for its support, and its revenue therefrom amounts to more than £4,200,000 (over $20,000,000) annually. Its leading merchants and manufacturers unhesitatingly affirm that this great industry is very largely dependent for its success on the influence of their technical school, which is one of the

best of its kind in all Europe. They declare that, among other benefits resulting from the school, it raises the tone and increases the knowledge of rising manufacturers and foremen, and by spreading technical education broadcast among industrious and ambitious artisans, very materially widens the field from which successful managers and specialists may be chosen.

At Mulhouse, Germany, for textile manufactures.

Mulhouse, Germany, affords another illustration of the fact that an industry may largely depend upon technical education. Its leading manufacturers claim that their textile museum, by its facilities for education, has exerted a most important and beneficial influence upon the leading industry of the district, some even going so far as to say that the trade could not in any degree prosper without the influence of this museum. Its principal citizens say that the town owes its great prosperity to the commercial and scientific knowledge principally acquired by its artisans in technological institutions, and to the commendable public spirit and enterprise of its citizens in promoting general technical education among all classes; also that this action has exercised a marked influence in suppressing trade jealousies, which have almost entirely disappeared from this community.

In suppressing trade jealousies.

At Verviers, Belgium, in maintaining its pre-eminence in certain manufactures.

Testimony to the same effect is given by employers at Verviers, Belgium. They claim that technical education is a great help to its industries. Their competition with other localities is very sharp, and the President of its Chamber of Commerce has publicly testified that their chief hope in maintaining pre-eminence as spinners and manufacturers rests on the superiority and not on the cheapness of their productions. This community has felt none of the evils of the late labor troubles in Belgium.

At Chemnitz, Saxony, for its textile manufactures.

Chemnitz, Saxony, is another city that freely acknowledges the benefits resulting from technical education. The

British Royal Commissioners declare that to the Chemnitz weaving school should be credited the variety and excellence of the textile manufactures of the district. The zeal of the inhabitants of Chemnitz for technical education will be appreciated when it is stated that up to 1883 they had contributed over $440,000 for the support of their industrial schools. In their conversations with managers and foremen there, the Commissioners were informed that the importance of technical education was everywhere acknowledged in Saxony. One of its largest employers said that the influence of the schools upon the industries of Saxony, by increasing the intelligence and skill of the artisan class, could not be too highly estimated. [Exhibit D.]

Effects of technical education at Roubaix, France.

In the city of Roubaix, France, considerable attention has been given to technical education. Mr. M. Carlos Delattre—a member of a commission appointed by the Mayor to investigate its effect on the industries of the town—said that during the ten years their technical weaving and dyeing school had been in operation, great progress had been made in the dyeing industry; that in every establishment where the sons of employers, foremen and workmen attended the classes, good results followed; that in the dye-works many of the young men can now make their own preparations; that there is *less need of supervision;* that *economy in production* has resulted from attendance at the school; and that *fewer mistakes* have been made, and *more reliable and efficient work* has resulted from its teachings.

Training school for marine engineers at Amsterdam.

The training school for marine engineers at Amsterdam was established by private enterprise, in consequence of the great need for skilled engineers in its merchant navy. Owing to the ignorance and incompetence of the men who had charge of the machinery of their vessels, shipowners

of Amsterdam suffered grievous losses, until they finally decided to found a school for training men to take proper care of their steamers. The originators of this school gladly testify to its economic value. (Second Report of Royal Com., Vol. I, p. 112.)

Improvement in French industries through technical education.

France has, of late years, been particularly active in making provision for technical education. An important report on the wool industry of France states that so great have been the mechanical improvements during recent years that since 1867 the cost of wool-combing has fallen off 25 per cent.; that since 1851 the cost of spinning has decreased more than half, while during the same period the wages of spinners and piecers have increased 40 per cent. The report, after stating that the improvement in weaving has been still greater, says: "In 1851 the goods were irregular and imperfect, while as early as 1878 they had almost attained perfection, with half the manipulation and double the wages paid to the workmen."

Effects of educating colliery foremen and engineers

It is commonly acknowledged by the proprietors and managers of mines that young men who have been educated in technological schools heat their boilers better and with *less coal* than do the other workmen, and that their scientific knowledge enables them *to escape many accidents* and to avoid *stoppage of machinery* and *repairs*. They are therefore very much sought after as firemen, and command higher wages than common firemen, because their services are more valuable to their employers. The Royal Commissioners mention the fact that several of the principal colliery firms of Europe have organized mining schools in connection with their works, and so convinced are the rest of the Continental colliery proprietors of the beneficial effects of this character of education that like schools are being generally established in the coal districts.

Superiority of Germany in engineering construction due to technical knowledge of her mechanics.

The generally recognized superiority of German artisans in the construction of roofs and bridges, both as to cost of construction, safety and durability, is to be attributed to the superior technical knowledge of her mechanics, which enables them to secure the necessary stability with the least consumption of materials and the minimum expenditure of labor.

Depression of English woolen manufactures due to superior technical education of rivals.

Comparing the worsted industries of France and England, the British Industrial Commissioners admit that France has far surpassed Great Britain in the manufacture of woolen goods. They say that while English depression in the woolen trade has been attributed to two causes—viz.: the greater cheapness of labor in competing countries, as represented by longer hours and lower wages, and the *superior technical education of their foreign rivals*—the cheapness of labor had very little to do with the depression, the real difference being found in the superior training and skill of the workmen of foreign nations, together with some minor local advantages on the side of the French manufacturers. They also say that since the establishment of a technical school at Bradford, equipped with various departments, qualified teachers, and the best obtainable apparatus and machinery for teaching designing, weaving and dyeing, the result has been that British all-wool goods of several varieties are taking their stand in English and foreign markets in open competition with those French and German goods which, but four years ago, seemed to enjoy almost a monopoly of public favor, and that, as a consequence, Bradford manufacturers are now operating as profitably as their rivals in any country. [Exhibit E.]

Influence of technical training upon the manufactures of Nottingham and Belfast.

The manufacturers of Nottingham are unanimous and emphatic in their testimony as to the important influence of technical training upon their industries. They say that

without this training some of their art-productions could scarcely have come into existence. The linen manufacturers of Belfast acknowledge that their ability to compete successfully with foreign nations in the more artistic productions depends on the higher training of their employes.

The beneficial results of high scientific and technical training on the chemical-color, beet-root sugar and alkali industries are especially noted by the Royal Commissioners. (Sec. Rept., Vol. I, pp. 222–9.) They say that the beet-root sugar manufacture, which is a great source of wealth to Holland and yields large profits to firms engaged in that business, often dividends of 100 per cent, is a striking illustration of the rise and successful operation of a most important industry, depending upon the intelligent application of the scientific principles of engineering and chemistry.

Effects of scientific and technical training on chemical industries.

The firms and corporations of Europe that have been foremost in securing skilled workmen have been most successful in their enterprises. As a result of improved methods of manufacture and new discoveries made by their trained employes, large profits are often realized by such employers.

Skilled workmen improve methods of manufacture & increase profits.

In short, it is the testimony of all who have studied the subject that technical schools, when rightly directed, give wonderful impulses to industrial pursuits by promoting scientific investigation and methods. Although at first this influence affects only those who attend the classes, it soon makes itself felt throughout the entire body of workmen of the community to which the school belongs, and the increased interest in scientific subjects on the part of employes, thus developed, in turn reacts to the pecuniary advantage of their employers; because mechanics who have been trained in the scientific principles that underlie

Techn'l schools promote scientific investigation and methods.

their handicrafts are thereby enabled to understand the technical publications affecting their trades, and to utilize new inventions and improved methods of work; while men uneducated in the rudiments of science ignore such sources of knowledge and, quite naturally, oppose all improvements as innovations calculated to work injury to the laboring classes. Cultivate a laboring man's intelligence to a point where it recognizes improvements and comprehends their nature; his opposition ceases, and he will himself likely invent improved processes, which will inure to his employer's benefit.

The truth of this is exemplified in the history of the rival silk industries of Lyons and Switzerland. The skill of the weavers of Lyons in the use of hand-looms was marvelous, but they combined no intelligence with it, for they had no scientific training. They clung tenaciously to those looms—relics of their ancestors—long after the introduction elsewhere of power-looms, and thereby almost wrecked the silk industry of Lyons. A leading merchant of that city, in speaking of this fact, recently said: "They have all, however, both masters and men, fallen behind the times in enterprise, clinging to traditions and old-fashioned methods, while their competitors have been organizing factories and teaching their workpeople the use of the power-loom, and other economic inventions. During the last ten years Lyons has, consequently, lost very much of its trade." Their enterprising Swiss competitors, on the other hand, engaged highly trained teachers, who brought to bear upon their work the scientific principles taught in the polytechnic schools from which they graduated, and introduced the inventions of which they there acquired knowledge. As a consequence the cantons now surpass Lyons in many kinds of weaving and in dyeing, as they do other trade centres in various industries.

The decadence of the silk industry in Lyons due to retention of the old-fashioned methods of manufacture.

Technical education has been the means of attracting capital not only to specific localities, but to countries. Indisputable evidence of this is found in Switzerland, and notably in Zurich, the manufacturing town above cited. For years a technical school has been conducted in this town at government expense, and when recently the Federal Council was disposed to lessen the usual grant for its support, the manufacturers showed, by undeniable evidence, that this single institution had in a few years been the means of bringing capital to the country to the extent of millions of pounds sterling.

Technical education attracts capital.

Other and even more forcible illustrations of like character might be cited *ad infinitum*, and can be furnished, if desirable, but they are substantially covered by the British Royal Commissioners, who, in summing up the results of their study of the effects of technical education on the continent of Europe [Exhibit F], say that they cannot repeat too often how strongly they have been impressed with the general intelligence and technical knowledge of the masters, managers and workmen of Continental industrial establishments. They have found that both classes, as a rule, possess sound and liberal knowledge of the sciences and principles upon which their industries depend; that they are familiar with every new scientific discovery and invention of importance, and can and do apply them to the development of their special industries, adopting not only the improvements and inventions of their own countries, but also those of the world at large.

The Br. Royal Commis'ers testify to the effects of scientific knowledge and its general application to special industries.

They further testify that a few years ago the question of technical education in England would have been a debatable one, but that now no argument is needed to convince English employers of its importance; that it has been tried and has given the highest satisfaction; that in

Technical education has passed its experimental stage in England.

Important English industrial centres that support science and art schools.

nearly all the great industrial centres—in the metropolis, in Glasgow, in Manchester, Liverpool, Leeds, Bradford, Sheffield, Nottingham, Birmingham, The Potteries, and elsewhere—more or less flourishing schools of science and art, of various grades, together with numerous art and science classes, are to be found in successful operation, and that their influence may be traced in the improved productions of the localities in which they are placed; in the decreased consumption of crude material, and in saving of time required for the performance of labor.

In short, one cannot study the present condition of European nations without being thoroughly convinced of the great economic value of scientific training to their industries, morals, and all that tends to shape the affairs of the world to their advantage and to the happiness and prosperity of their people.

Testimony of Prof. Huxley on the economic value of scientific knowledge.

Further testimony on the economic value of scientific knowledge in connection with the staple industries is furnished by the well-known Prof. Huxley, who, answering the question, "What bearing do you consider that superior general culture in Germany has upon the industries of Germany?" said:

> "The bearing of it, if I do not misapprehend the matter, is this: The development of industry under its present conditions is almost entirely the effect either of the application of science, or of the development of mechanical processes of complexity, requiring a great deal of attention and intelligence to carry them out; and I do not think I am wrong in supposing that the advance of industry in all countries depends on employers being able to find to their hand persons of sufficient knowledge and sufficient flexibility of mind to be able to turn from doing the thing they have been doing and to do something different, according to the nature of the improvement that has been made. It is there, I apprehend, that the advantage of such scientific training as can be got in those small universities of Germany is manifested. Scientific training is of infinitely greater importance in the case of such a man than literary training, because no amount of literary training ever enables a man to understand what it is to deal with facts at first hand; it does not conduce to that habit of mind which is most useful to a man in the practical affairs of life. Scientific training does conduce to it, though it may not produce it."

Of Professor von Helmholtz.

Prof. von Helmholtz also points out not only the general advantages, but the absolute necessity, of employing, as

heads of departments, persons conversant with the theory of their work, and able, by virtue of their scientific knowledge, to anticipate results, and to calculate beforehand the quantity and quality of material required, as compared with those who, lacking such attainments, are compelled to adopt—often at greatly increased cost—the more empirical methods of repeated trial.

Agency of technical schools in supplying trained specialists and developing industrial arts.

In short, it is almost universally testified by the observant that technical schools have supplied a long-felt want for trained specialists, who have been, and constantly are, the source of unexpected economies; not alone because, through their scientific knowledge, superior training and habits of thought and observation, they are able to anticipate results, and to give intelligent direction to their subordinates—inspiring them with interest, and often enthusiasm, in the discharge of their duties—but also because, through the utilization of the latest discoveries of science, they improve methods of production, turning out superior articles with marked economy. Through the agency of such schools originality has taken the place of servile imitation; decaying industries have been revived, and new ones promoted; while they have exerted a most marked influence in developing the intelligence and skill, and consequently in securing the permanent prosperity, of the industrial classes generally—the people by whom the work of the world is done, and upon whom national, no less than corporate and individual, wealth depends—by enabling them to develop the sources of wealth peculiar to each country.

Scientific knowledge promotes the welfare of employes as well as of employers.

Ability on the part of laborers to understand something of the principles that underlie their various handicrafts is productive of good results, not only through lessening the cost of production, but also in advancing the welfare of the employes themselves, by enabling employers to pay better

wages for articles of superior workmanship and manufacture, from which they derive greater profits.

Education promotes industry and thrift.

During its last session, the British Parliament was compelled to take into "*serious consideration*" the condition of the overcrowded districts of London and other large industrial centres, and the debates in the House of Commons developed an almost unanimous opinion that only through government furnishing, in some form or other, additional facilities for industrial education lies the temporal salvation of their idle population—semi-paupers through lack of knowledge of how to work. While our own General Government is not parental, in the sense that European Governments are, our State and municipal governments do, in theory, very nearly approach that relationship, and can exercise their functions in no more beneficial way than by fostering the *industrial* education of their people.

In his report for 1868, the French Minister of Public Instruction gave testimony as to the valuable results of technical training as follows:

> "Science continues its discoveries, and every day places at the disposal of industry new and serviceable agents; but in order to be applied, those agents, which are sometimes very delicate and sometimes very powerful, require to be skillfully handled. This is the reason why, in the present day, industrial progress is so intimately connected with educational progress, and why questions which it is the duty of the University to examine and to solve have acquired so great an importance as regards the material prosperity of a nation."

A most noteworthy example of the truthfulness of this statement is found in Switzerland—a country beautified by Nature with lakes and mountains and a climate that have made it the beloved of artists and poets, but denied ports, navigable rivers, canals, mines, fertility, or those other *natural* gifts which are the usual foundation of the prosperity of other civilized States. Yet from among those sterile rocks there are yearly exported industrial

products not only in excess in value of all the importations of the cantons (including the two hundred and odd millions of francs' worth of goods which they purchase from France alone), but more than sufficient also to cover the cost of internal administration. Industrial education alone can claim the credit of elevating this nation—which in former times cultivated mercenary warfare as its sole occupation—to the first rank in those manufacturing industries requiring individual skill and intelligence.

I cannot more forcibly close this section of my report than by the following quotation from the work of the eminent scientist, engineer, builder and educator of Great Britain, J. Scott Russell, on SYSTEMATIC TECHNICAL EDUCATION FOR THE ENGLISH PEOPLE, 1869:

"I may add that in every country where technical education has taken root and had time to bear fruit, I also find unquestionable proofs of the rapidity with which increased intelligence and enlarged knowledge bring increase in employment and remuneration. From my personal experience, I may say that within the last twenty-five years I have seen large branches of commercial trade leave one country and plant themselves in another, because the workers of the one were educated and those of the other uneducated. And I have watched nations rising into importance and power by education and by the order, organization and efficiency which education bestows; and other nations lagging behind and losing their place by reason of their unwillingness to educate either the higher or lower classes of their people." (P. 76.)

DEVELOPMENT OF INDUSTRIAL EDUCATION IN THE UNITED STATES.

If the results of an educational system can be ascertained from a close inspection of those industries in which the mass of a country's population is engaged, and in which their knowledge is displayed by the fruits of their labor, it will be found that the national system of popular education in the United States fails entirely in accomplishing its mission, in several important particulars. For example, in the public schools our youth are, as a rule, entirely untaught in even the rudiments of industrial

Public schools in America fail to prepare for industrial pursuits.

occupations, and upon passing from the school-room are generally utterly incompetent, unassisted, to earn a livelihood in any trade or pursuit requiring manual dexterity. Even our high schools leave their graduates to drift, by accident or unintelligent direction, into avocations generally foreign to their abilities, and, as a rule, with few exceptions, unequipped with that character of knowledge or expertness without which a comfortable living becomes difficult—prominence impossible. It is commonly accepted as fact that a good elementary education such as is afforded by our public-school system gives a child that which will carry it well along in life; but this is true only of agricultural, or at most of sparsely settled districts, and is then true only within limitations. In the crowded countries of Europe, and in our own Eastern and Middle States—wherein labor and industrial problems already closely approximate those in Europe—there is an increasing recognition of the fact that, though good school tuition is always important, to be effective it must be supplemented by such technical knowledge and training as will enable the student to survive in the battle for existence—which is deadliest in those sections where dense populations cause the sharpest and most active competition. In other words, the tendency of our public schools is—by elevating pupils above their actual or probable stations in life, and prompting in them desires and aspirations of which there is little chance of fruition—to turn out a large class of consumers, who fail utterly of success in the professions and kindred occupations, under conditions which, had their efforts been directed to mechanical or other industrial pursuits, would have made them efficient producers. Most of the education acquired under our common-school system is temporary and only preparatory for

School training should be supplemented by technical knowledge.

Public schools turn out consumers, not producers.

such higher studies as do result in business qualifications; whereas, to be of immediate benefit to the masses, school education should of itself give the graduate an earning capacity. Says Judge MacArthur, in a recent and interesting treatise on popular education: "To graduate one taught to think only, is like sending a ship to sea in charge of a navigator, without a single person on board who can understand or execute his commands."

Popular education should include the cultivation of physical dexterity.

Knowledge and mental discipline alone do not constitute all of education. To be practical and useful to most of those who must earn their own livelihood, education must also afford physical dexterity, with special reference to the industrial pursuits of life. As the result of this absence of instruction of a practical character, a remarkably small percentage of our public-school graduates in the Middle and in the Southern States engage in any kind of manual labor.

Higher educational institutions should combine industrial and scientific instruction.

Recognition of this lack of *utility* in our educational system has, of late years, become quite general, resulting in variously directed efforts to engraft upon our higher-grade institutions industrial and scientific instruction, and the colleges and schools whose curricula embrace those subjects which fit our boys and girls to participate in the practical work of life are now rapidly increasing. There have long existed in the United States a certain number of educational institutions wherein special attention is given to technical and scientific training in mining, civil and mechanical engineering, applied mathematics, physics and the natural sciences, which are fully equal to the best of similar schools in Europe. Among the most prominent of these are the School of Agriculture and Mechanical Arts of Cornell University, the School of Mines of Columbia College (N. Y.), the Massachusetts Institute of Technology, the Lawrence School of Science in connection

Colleges which afford advanced scientific instruction.

with the Harvard University, the Pardee Schools, the Stevens Institute at Hoboken, the Rensselaer Polytechnic Institute, and the Sheffield School at Yale; but the high tuition fees charged by these and similar schools make instruction therein available only for the wealthier classes.

Elementary science—how taught in our colleges, academies and high schools.

In addition to those institutions which afford special facilities for advanced instruction and original research in science and the mechanic arts, in most of the States elementary science is now taught in numerous colleges, academies and high schools. While this instruction, in point of cost and preliminary educational qualifications, is generally within the reach of the masses, the subjects taught and, as a rule, the manner of teaching them, have but little practical bearing on industrial pursuits. However, in the last few years considerable progress has been made in introducing a substantial help to industrial education—that of manual training schools—and already their feasibility and desirability as a feature of popular education have been practically demonstrated. Well equipped schools of this character are to be found in St. Louis, Chicago, Toledo, Philadelphia and Boston.

Popularity of manual training schools.

The secret of the popularity of this kind of education is to be found in the *natural* and *practical* combination it makes of *intellectual* and *manual* training. Both thought and action are developed equally, and the skill acquired at school, together with the respect for industrial pursuits there fostered, makes their pupils useful, wealth-producing citizens.

Success dependent upon a thorough understanding of objects for which the school is instituted.

The success of the manual-training schools at Chicago and St. Louis, and most other points where inaugurated, has far exceeded the sanguine expectations of their originators. That our own Baltimore school, as appears by the dissensions in its management, to which so much

publicity has recently been given, has not been equally successful, simply proves that the objects for which it was instituted, and the methods by which practical technical education is to be accomplished, have not been understood by those controlling its policy and operations. The results that have already been achieved elsewhere by kindred schools prove that efforts to combine mental and manual training are not visionary, while the liberal patronage which such schools, properly conducted, have uniformly received, is abundant evidence of the demand that exists for the training they afford. But these schools can each provide for only two or three hundred boys at most, while there are thousands more—equally anxious to receive the same kind of instruction and equally meritorious—who are denied, through lack of facilities, their equal rights to public mechanical instruction.

Combination of mental and manual training not visionary.

A few years ago the United States Commissioner of Education requested a number of large and experienced employers of labor, and others qualified to form reliable opinions on the subject, to express their views upon the comparative value of educated and uneducated labor in America. Answers were received from many men whose acknowledged ability and experience entitle them to consideration as authorities upon the subject of this report, and I therefore invite your thoughtful perusal of the few selected answers printed in Exhibit P. The evidence thus accumulated by Commissioner Eaton shows a very general concurrence on the part of our farsighted employers in the foreign testimony above outlined; but there seems to be far less appreciation in the minds of our statesmen and educators of the fact that, by making public-school instruction—which has by elevating the general intelligence measurably increased the productiveness and efficiency of

labor—preparatory to special technical training, they will not only directly promote the nation's industries, but also make general education far more popular with the masses.

Report of Mr. Wm. Mather, of England, on technical education in the United States.

Pursuant to the idea of avoiding *ex-parte* evidence in this report, in further analyzing the state of technical education in the United States, I am fortunately able to avail of the labors of Mr. William Mather, who, as the representative of the British Royal Commissioners charged with an examination into industrial and technical education in America, patiently and exhaustively investigated, not long ago, the educational and industrial institutions of the United States. Mr. Mather is an accomplished expert in technical education, and from no higher source could disinterested and unprejudiced testimony on the subject be obtained. Extracts from his report are given as appendices, and a few of his observations upon our educational system, peculiarly pertinent, are here quoted.

Says Mr. Mather:

"It is much to be deplored that in the majority of institutions in America where science is taught in the abstract, there are no departments arranged for such technical training as exists in some I have described.

"The demands made upon those which give technical instruction are greater than they can satisfy. This accounts for the high fees charged, and also for the fact that the advantages of such technical schools are in the main confined to the sons of wealthy manufacturers or professional men.

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"All these evidences of scientific skill (American mechanical contrivances) speak well for the methods of education in the recent past, so far as it goes; but other influences, such as 'necessity the mother of invention,' and the presence in America of foreign experts, will account for much of the rapid growth in the mechanic arts.

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"It is, of course, in the more recent structures and modern mechanical appliances that the evidence of scientific truths and methods is observable. The rough-and-ready contrivances of early railroad development indicate originality and 'mother wit'; but in the waste of material and crudeness of design may be noticed the absence of technical or scientific training on the part of those who conducted extensive engineering or mechanical operations in those days. The gradual diffusion of science is very marked in the rapid reconstruction, during recent years, of the great railroads of the past, and in the new main lines. Also, in railway plant generally the old is being replaced by the new, and the latter exhibits high theoretical knowledge combined with practical ingenuity.

"The Americans undoubtedly owe to European engineers the rapid advance they have been able to make in their public works. The conservation of water-power for the use of the mills at Lowell and Lawrence, in Massachusetts, is due to the eminent hydraulic engineer, Mr. Frances, an Englishman, who practised for 40 years in America. The water-rights of a district are held in trust for the whole community by a board or corporation elected for the purpose. The power is distributed according to the share which may be purchased or rented by the users, but regard is had to the rights of all, and its utilization requires great skill and knowledge to prevent loss of power. Mr. Frances has had charge of this important work for many years, and is deservedly esteemed as the highest authority on hydraulic engineering in America. Although a lucrative field was, in the early days, open to European engineers and machinists having a thorough scientific knowledge of their profession, yet it is evident that they found apt scholars, who, as they acquired some theoretical science, launched out into new paths untrammeled by the traditions of the older countries.

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"It would appear that employers and foremen no longer value the labor of boys under 17 years old in machine shops. There is, in fact, a marked discouragement shown by managers of most of the works I have visited to the employment of boys. The assistant manager of the Edgar Thompson Steel Works 'thinks boys under 18 years old ought to be at school.' He was educated at the School of Mines, Columbia College. The whole tendency is to engage boys as they do men, only for what they are worth. The evil of this will be severely felt in the future, if not mitigated by great changes in education, for the reason that many boys are obliged to leave school at 14 or 15, and if they are not allowed to enter the skilled trades they will be thrown upon casual employments or unskilled pursuits for temporary gain and a livelihood. Thus a mass of incompetent and unskilled laborers would grow up incapable of going out West, and would become a drug upon the labor market of the East. It is undoubtedly a shortsighted policy on the part of employers to discourage the employment of boys, without aiding those movements which, in the form of industrial schools, would enable a boy to qualify for service at 17 years old at a higher rate of wages than he could probably get at that age but for this training.

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"The future development of American industries will depend upon a population not compelled to dare and endure and experimentalize for 'very life.' In the past the waste of material has been excessive. To make the best use of a given quantity of material requires a sound knowledge of its properties and of its disposal in the arts and manufactures by scientific methods. In this direction the technical and science schools already instituted have accomplished much in providing foremen and managers, chemists, miners and intelligent employers in the engineering and manufacturing industries. Some extensions of these institutions are now being promoted. One significant indication of progress in this direction was afforded me during my travels. I attended a convention of about a thousand teachers, professors and principals of schools and colleges, at Saratoga, and another similar gathering in the White Mountains. The discussion of technical and industrial training was the chief feature of the conventions. I was much impressed by the high qualities of culture and character which distinguished this truly 'Grand Army of the Republic' in its 300,000 teachers, as represented at these meetings. If this force should be directed by a change of tactics, so to speak, in the schools, to scientific and technical instruction, and to less concentration upon purely literary subjects, there can be no doubt that America will solve the industrial-education question more rapidly than any other country, and utilize it in the further development of her inexhaustible resources.

"It must not be supposed that Nature has bestowed her gifts over this continent in such wise that they can be enjoyed without much skill and labor in the

gathering of them. No country offers more difficult problems to the engineer, the agriculturist and the manufacturer. A climate of extremes; a scarcity of water in the West; the difficulties of cheap transport and distribution, all require the highest qualities of self-reliance and endurance, with scientific knowledge, in the progress of the future.

"It is remarkable that, in the great centres of the mining and iron-producing districts, where also a large amount of mechanical construction is carried on, as, for instance, in Pittsburgh, Chicago, Detroit, Cleveland and Philadelphia, so little has been done by the owners of large establishments, or by the town or State authorities, in the direction of technical schools or evening science schools. These industries represent a large proportion of the working population in those large cities, and yet the owners of works have to rely upon the scientific knowledge obtained through many institutions remote from these districts. Pittsburgh is lamentably devoid of facilities, either in the shape of libraries, museums, science schools or technical schools, notwithstanding that the manufacturers have enjoyed the benefits of, and accumulated vast wealth from, highly protected industry. There is not even a public library in the city, although there is a population of about 200,000.

"In Cleveland a movement is being promoted to establish a technical school. I have already stated that Chicago is building a manual-training school.

"It is a noteworthy fact that, among all the many munificent gifts which have been made by private individuals for the cause of education, amounting in the aggregate to many millions sterling, very few have emanated from those who have derived their wealth from the scientific industries, all of which have been protected and owe much of their success to foreign skill. On the other hand, merchants, bankers and professional men are largely represented in the noble list of benefactors connected with some of the best educational institutions of the country.

"I have not met with any institutions for technical training having any bearing on the textile industries. The knowledge of chemistry acquired at the various institutions which I have described is, of course, utilized more or less in dyeing, printing and bleaching; but there are no schools in which the knowledge of the nature and qualities of fibres, and of the various processes in working up the raw material — silk, cotton or flax — is taught. In all the manufactures into which taste and design enter, the Americans have to rely almost entirely upon European aid. It is intended, however, so I am privately informed, to establish, in one of the centres of textile industry, a large institution in which a thorough and comprehensive industrial training will be given in textile manufacturing, together with that theoretical knowledge which is necessary to the production of the highest quality of fabrics.

"I have not included the Southern States in my investigations by a personal visit to the various important towns, for the reason that education, for the present, is at a low ebb in that part of the country. There is, however, a very strong movement already apparent for the promotion of mechanical and textile industries in the South. The enormous resources of some of the States—Alabama, for instance—where mineral wealth abounds, have attracted capital for the rapid development of various manufactures. This, together with the proximity of the cotton-growing districts, points to a development, in the near future, of many industries which, until recently, were unknown in the South. * * * The different colleges established by the assistance of the 'Land Grant' appear to have done good work, in connection with agriculture, in the South, in teaching the elements of science and in providing a liberal education for those students whose means have enabled them to attend. The mechanical arts have had less attention in such colleges than in similar institutions in the North, in consequence of the difference in the occupations of the people.

"The institutions for the advancement of the workpeople, other than schools and colleges, are not numerous in America. The long hours of labor (at least 60 hours a week) leave but little leisure for the working classes either to study

or to seek recreation. There is no half holiday on the Saturday. There are no holidays during the year of more than one day at a time, and that only a few times in the year. Libraries and reading-rooms, although amply provided in most cities and towns, are not available as universally as in England. Clubs and recreative institutions, promoted by the employers for the employed, are not prevalent. There is not much interest manifested by employers generally in the social condition of the people. This may be accounted for by the number of joint-stock companies."

If the few institutions affording technical education now in operation in the United States have been able, in a short time, to accomplish so much in those branches of mechanical industry in which Americans are confessedly pre-eminent, as is shown in the testimony from which extracts are appended to this report; if, through our inventive and mechanical ingenuity we are, as Mr. Mather and other intelligent foreigners say, taking high rank in those arts and manufactures to which fertility of resource and invention is most effectively applied—and that, too, notwithstanding our totally inadequate provision for industrial education—with what hope might we not look forward to equal or greater pre-eminence in other arts and industries of which their technical schools have given foreign countries a practical and profitable monopoly?

Our national prosperity not due to superior technical training, but to other causes.

That our national prosperity has been greatly promoted by the pre-eminence of certain of our manufactures in the markets of the world is undeniable, but that this successful competition has been due not to the *superior* intellectual cultivation, or even the *manual skill, of our native artisans*, but to very different causes—such as abundance and quality of crude material; superior facilities for economical manufacture; the aid of imported skill, and those natural and untaught qualities to which Mr. Mather and others pay such high tribute—is likewise easily demonstrable; and it is sad to reflect what greater success might have been achieved by combining therewith that high degree of intelligence and skill that European nations, under the

compulsion of competition, are sedulously cultivating in their industrial classes. We must soon place greater dependence upon the quality, finish and unique designs of our exported products for success in unprotected foreign fields, and it will be well for us to profit *now* by the experience of our rivals across the Atlantic. It is wiser and cheaper to discount defeat than to repair its effects. The season of prosperity is the best time to provide against the depression which, with certainty, follows; and the knowledge and skill of the specialist are most efficiently and economically applied to an industry in its infancy or when it is in a depressed condition.

Achievements of industrial schools in Europe show what might be accomplished by similar schools in U. S.

From the foregoing it will be noted that the careful, thorough and extensive investigations of the English Government, supplemented by the published observations of individual students of recognized ability and accuracy, have resulted in the uniform testimony that polytechnic and other science schools in Europe and the United States have, without exception, stimulated national and local industries, manufactures and trades, and, in a large proportion of instances, have transplanted or developed new industries. Even the few—and not selected—illustrations of this fact which the compass of this report permits to be made therein, bear forcible testimony to the achievements of such schools [Exhibits F, O, and Q], and are suggestive of the profit which our more populous districts—and especially those seaboard cities which, as the termini of our great trunk lines, become the focus for many manufacturing, mechanical and other interests dependent upon the products which they transport—might derive from the investment of a reasonable amount of corporate and individual wealth in the establishment of similar schools, adapted, of course, to the wants of our peculiar industries and institutions.

While it may be said, with some show of truth, that the most practical technical schools are great workshops, still the ordinary workshop does not *yet* combine mental instruction with manual training, while our science teaching is of too high a grade to be assimilable by the ordinary mechanic and mechanical apprentice, and is too theoretical to be adaptable to the current work of our shops. Not only is there too little *application* of science to our various handicrafts, but there is, for the most part, a sad lack of intelligent effort to teach apprentices *in* our workshops that manual dexterity which, at least, they are supposed therein to acquire. Now that the old system of apprenticeship is rapidly becoming obsolete, the question of what shall take its place in the way of educating and training the youth of our working classes becomes an important consideration for all who are interested in our national welfare and in the development of our industries Skilled labor must be had from some source, and we cannot afford to import it in bulk, if for no other reason than its expensiveness. Our own people have the first claim upon our industrial occupations, but if we are to compete for foreign trade they must be so trained as to make and keep them, in knowledge and skill, at least the equals of foreign workmen. The most practical way of affording them this training is to build up special low-grade science schools, where the instruction shall be of such a character as will directly bear upon our arts and manufactures; for if any lesson can be drawn from the study of technical education abroad, it is that progress and success are most readily and cheaply attained by means of combined theoretical and practical instruction, and that our designers, our superintendents and our foremen, *at least*, should be scientifically and practically trained experts. [Exhibit G.]

Workshops do not combine mental and manual training, and our present science teaching is of too high a grade.

Something needed to take place of the old system of apprenticeship.

How to make our laborers the equals of foreign workmen.

Without dwelling further upon this point, however, the foregoing and the several exhibits hereto sufficiently demonstrate how much the United States already owe to those schools wherein the application of science to the mechanic and useful arts is *practically* taught [Exhibit Q]; as also that, as a people, we have been singularly backward in discovering how potential a factor in internal politics and in our domestic and foreign trade relations the systematic cultivation of our laboring classes in technological knowledge could be made.

The missing link in our educational system.

It is obvious that to supply the missing link in our system of national education there must be either a modification of the curriculum of our public schools, as suggested by Mr. Mather, or we must establish schools intermediate between our grammar schools on the one hand and our high schools, academies and colleges on the other; which, while affording our youth those opportunities and facilities for technical instruction that are absolutely necessary to the development and success of many languishing industrial and manufacturing interests, will also fit them for the higher duties of American citizenship.

Cost and character of national education.

In 1880 the United States contained 189,000 elementary schools, having 9,720,000 pupils. Our national and State expenditures for the support of public schools now largely exceed $100,000,000 per annum, and the value of our school property is not less than $200,000,000. These expenditures exceed those of England and Wales nearly five times, and those of France nearly four times. In the number of pupils and the expenditure of money on our public schools we lead the world, and yet neither our State nor national appropriations in aid of *industrial* education for the working classes have been sufficient to make more than an impression upon the great mass of technically uneducated labor of the country. [Exhibit L.]

Says Judge MacArthur, in his excellent work on Education in its Relation to Industry:

"To compete successfully with foreign work we must have a class of artisans as highly cultivated in workmanship as those we import from over the sea, and this skill can be acquired only by practice in their respective handicrafts. It is true that with us applied science and mechanical powers have superseded, in a great measure, the burden of heavy labor; but the quick eye, the expert hand and the acute taste can never be dispensed with in the manual processes of the arts and manufactures. To meet this imperative demand for first-class workmen, without submitting to the exactions and competition of foreign work, we must educate the constructive ability of our youth during the period of life which is now devoted to study alone. We have developed, in a high degree, the arts of manufacture, but we are nearly without any American artisans in the trades connected with design, and are consequently deprived of the acknowledged sharpness and ingenuity of our countrymen in helping on American industries. This wide and remunerative field of labor is left to be occupied by partly educated and skilled foreigners. We have excellent schools for all sorts of instruction in the essentials of mathematics, history, literature and philosophy, but we fit nobody with either skill or knowledge in any particular habit of industry.

"The period seems to have arrived when institutions of industrial science and education can no longer be postponed in our country, and when they must be tried on as extensive a scale as those witnessed abroad. There seems no reason why the institutional system should not be adapted to the tradesman, the artisan and the manufacturer, as well as to the more pedantic professions, in which men are so thoroughly trained. The reform of our taste has commenced by the purifying influence which proceeds from, and which will gradually make its way through, the community from the universal teaching of drawing. An appeal must now be made in behalf of teaching the processes of production, as well as the principles which shall guide the work. The use of tools and machinery does not come by intuition, and industrial knowledge ought to include instruction in their use."

Absence in our country of institutions for combined general and mechanical education.

With a very few exceptions there is, in our country, a conspicuous absence of institutions for combined general and mechanical education of the character which, in France, Germany and in other Continental nationalities, are regarded as the great source of national wealth, and which are beginning to play a most important part in the promotion of those trades and manufactures with which England is coming to the front.

Act of Congress, July 2, 1862, providing for industrial education.

Though Congress, by its act, approved July 2, 1862, setting aside a large portion of the territorial wealth of the nation for industrial education, inaugurated a sagacious scheme for "teaching the processes of production," and their underlying principles, which, wisely and energetically

followed up, would in a short time have placed the United States in the foremost rank of civilized nations in the theoretical knowledge and skilled training of its work-people, and have developed many old and created new industries, thereby more rapidly enriching the country, most of the provision made by that act for industrial and scientific teaching of the masses has, by reason of the paramount importance attached to agriculture in most sections, been absorbed in the endowment of agricultural colleges—so called. Whilst these colleges, as first contemplated, were to have departments for teaching mechanic trades, most of them have drifted away altogether from the original intention of the authors of the act, and there is in them, generally, little or no effort to combine theoretical instruction with practical mechanical training in other than those branches of knowledge closely related to agricultural pursuits. Much remains to be done before they can be of any material advantage to manufacturers and others requiring skilled labor. If their managers are to fulfil the design of Congress, they must, much more than at present, turn their attention to the training of experts in mechanical and industrial arts; for it is only in schools devoted to instruction of this character that the poor youth of our country can obtain such instruction and training as will enable them to acquire and maintain that supremacy over foreign rivals in important arts and manufactures to which our many advantages entitle us. It is true that agricultural colleges have, *per se*, a great mission to fulfil, especially in our Western and Southern sections; but as Congress, by express terms, provided and intended its appropriation of school lands to inure to the advantage of all industries equally, and as many important interests of the country require that technological instruction

Course of study in agricultural colleges not what the authors of the act intended.

Mechanical as well as agricultural colleges are needed.

should be placed above mere dependence upon individual support, the remodeling of those colleges is necessary to bring them into harmony with national legislation, and such action would probably stimulate State and municipal authorities to effectively supplement national appropriations.

Our best schools are those sustained by endowment of private individuals.

At present our most efficient institutions for affording technical education are those established and sustained, wholly or in part, by the endowments of private individuals. It is not to be inferred, however, that this assertion implies that Government and State schools *might not* be made equally—and even more—efficient than similar private institutions. But it happens that, as a rule, endowments have been left under conditions and instructions more specific than in the case of Government and State grants, and have therefore been less easily diverted from their legitimate objects, and are, besides, less susceptible to those influences which with us almost uniformly prostitute public educational funds to political or sectional purposes. Still it is a stern fact that should be recognized by all would-be founders of educational institutions, that this character of *trust*, especially, affords much opportunity for misapplication, even under the most carefully guarded legal phraseology, and that the most conscientious trustees and managers are not proof against the temptation of construing, and even forcing the construction of ambiguous terms, in harmony with their individual predilections. Moral:—Execute your own benefactions.

Desirability of donors executing their own benefactions.

In just what manner private appropriations and city systems of public instruction should deal with industrial education is a grave problem, but the labors of the Bureau of Education at Washington have resulted in the collation of a mass of data, not only upon the needs of the country

in this regard, but also in reference to the many experiments and efforts (mostly successful) to inaugurate technical education in various localities, that will greatly aid in its solution. Among other of this Bureau's reports, Circular of Information No. 1, 1885, containing the observations and views of John D. Philbrick, LL.D., State Superintendent of Public Instruction in Connecticut and, later, Superintendent of Boston Schools, upon the city-school systems in the United States, is of special value and interest to boards of education, school superintendents and educators generally. Extracts from those pages of his report devoted to the consideration of industrial education, and the necessity for it in the United States, are appended hereto, and their careful perusal is earnestly recommended. [Exhibit N.]

Conclusions of Dr. Philbrick upon the subject of industrial education in the U. S.

Summing up his conclusions as to what should be done for industrial education by city systems of public instruction, Dr. Philbrick says:

"Without abating our zeal or contracting our scheme of provision for general education, there remains much to be done by our city-school systems in providing that kind of instruction and training which fits persons, in part at least, for some particular mode of gaining a livelihood. The provisions for this purpose which seem desirable in the present stage of pedagogical experience and opinion are here briefly enumerated:

"(1) A modification of the curriculum of elementary instruction which will render it better, not only for the purposes of general education, but also better as a direct preparation for many industrial pursuits. This modification consists, in brief, in throwing overboard a considerable mass of the useless details of some of the branches now taught, in applying more practical and comprehensive methods of teaching all the subjects, while always aiming at the shortest and most direct means of communicating and enabling the pupils to acquire useful knowledge, and at the same time ignoring processes and exercises merely for the sake of what is called symmetrical development of the mental faculties; thus making room for drawing (both freehand and mechanical), the rudiments of bookkeeping, the rudiments of practical geometry, physics, chemistry and natural history, modeling and carving for boys, needlework for girls. I omit the workshop for boys, because I think that up to fourteen years of age the above studies, in connection with gymnastics, would be more profitable as a preparation for apprenticeship, and I think boys ought to complete their elementary education at fourteen years of age, and, if they have not, the more reason why they should not then divide school work with shop work.

"(2) To teach girls, in all grades of public instruction, sewing and cutting and fitting, and, besides, special schools should be established for instruction in the advanced branches of needlework, cutting and fitting, and perhaps millinery.

"(3) To establish everywhere, in small cities as well as large, thoroughly equipped evening industrial drawing schools.

"(4) Evening high schools should be widely disseminated, giving instruction in more or less technical branches, such as bookkeeping, commercial arithmetic, stenography, practical geometry, drawing, etc.

"(5) Evening schools devoted exclusively to technical branches, like those in France.

"(6) To establish in the larger cities one or more apprentice schools like that in Paris, on the Boulevard de la Villette.

"(7) The establishment of simple manual-training schools, as they may be required, like those in New Haven, Boston, and Peru, Ill., for boys who have completed their elementary studies and for boys already in the grammar schools who wish to attend them out of school hours, whether in the evening or daytime.

"(8) To establish in the larger cities manual-training schools, after the pattern of the St. Louis school and the school of mechanics connected with the Boston Institute of Technology.

"(9) The general establishment of schools of practical cookery for girls, after the pattern of those which have been so successful in the city of London."

Reference has been made to departments in our principal universities for technical and scientific training in mining, civil and mechanical engineering, physics, and the natural sciences, and to other and more directly technological institutions for teaching low-grade science, and the character and plan of instruction therein pursued are illustrated at length in the appendix [Exhibit L]; but all these schools and departments, aggregated, are insignificant in number, and in most of them instruction in the mechanical arts has not been strictly adhered to, having been obscured by the literary and art-science sides of education, as therein taught. That this tendency is a very grave danger in technological schools generally, is very apparent from a study of those in England, where most of the institutions established purely and simply for technical instruction are already drifting into devotion for the higher branches of the natural sciences and mathematics, to the exclusion of drawing, applied science, and mechanical teaching.

Present provisions for industrial training inadequate.

Tendency to ignore practical subjects.

Judge MacArthur says that while we have schools for all sorts of instruction in mathematics, history, literature and philosophy in abundance, they fit nobody with either knowledge or skill in any particular branch of industry.

In the absence of provision for manual training and for a practical application of theoretical knowledge there is, of course, no acquisition of skill, but there is a notable tendency to beget dislike for those pursuits that require manual labor. It is high time that those interested in public education should display a danger signal in connection with our national system of elementary education, which *also* drifts to the *literary side* with a rapidity that should alarm our social economists. The storing of the memory with a multitude of extracts from books which, for a brief period after school life, may be retained and repeated as a proof of education, is altogether misleading and useless for boys and girls who must face the stern realities of making their own living. The character of teaching in the public schools of America is rapidly creating a distaste for manual work and industrial pursuits in general, and it would be well for our public teachers to make an earnest attempt to modify their instruction, in the direction of devoting more time to subjects of a practical nature, thereby promoting tastes for industrial pursuits based upon knowledge of the principles of the natural sciences applicable thereto.

Lack of manual training.

Schools devoted to mathematics, philosophy, literature, etc., create distaste for manual labor.

Reviewing briefly the voluminous data showing the status of technical training in the United States, it is to be noted that, while provision for some kind of industrial education is now made in many of our universities and colleges, it fails to meet the greatest demands of the times in the following respects:

Defects in existing schools affording industrial training.

1.—The instruction is too expensive for workpeople. But few of our mechanics and artisans could afford to pay the high tuition and meet the other necessary expenses, even if they had the means of support during the three or four years necessary to complete the course of instruction.

Too expensive.

2.—The course of studies in these institutions is much too far advanced for the mass of our people—the conditions of admission being so rigid and far-reaching that only those persons who have already had superior school faciiities are able to comply with them. Hence most of those universities and colleges that do make some provision for technical training are practically closed to the great majority of our laboring classes, who, being unable to pass examination on *all* the numerous subjects required for admission, are excluded from any of their departments of study. There are also radical defects in present methods of ascertaining the fitness of young people for pursuing technical studies. Those methods generally only develop how much cramming has been done by and for the candidates, whereas far greater consideration should be given the native ability, the previous educational facilities, the present circumstances, and the probable future career of the applicants. Many who, from lack of preliminary training, may not be able to take up and complete all of a prescribed course might still make good headway in special studies, if they could only be admitted to the classes.

Beyond reach of workpeople.

3.—The instruction in most of our institutions is too theoretical. In order to benefit workmen and employers it should be better adapted to practical ends. Students in industrial classes should have greater facilities for visiting shops, factories and mines, and for studying their operations, and should be examined with reference to their proficiency in *applying* scientific principles to the numerous mechanical processes they witness, just as students of botany visit fields and forests and study flowers and plants, or as students of medicine go to the dissecting room to learn the human body, and to the laboratory for practical study of chemical compounds. For a mechanic to be able

Too theoretical.

to dissect a machine that he has to run and keep in order, and to understand the nature of the material of which it is made and the office of each part, so as to be able to take the machine apart, mend that which is broken or out of shape, and put the whole together again, is just as essential as that the surgeon should understand the materials, construction and functions of the human body, in order to repair it intelligently and well. But the students in most of our college classes know machinery only as they see cuts of it in their text-books. They study about wheels and pulleys and levers and screws, but rarely see them in operation. They learn the laws of electric force, without acquiring the mechanical power to properly arrange a battery when the materials are put into their hands. They learn the formulæ of chemistry, but are unable to undertake the simplest experiments without endangering their own lives and those of others.

Students not taught to observe and to do.

4.—Another important deficiency is the absence of provision for evening instruction of the masses of mechanics who are compelled to labor during the day for the support of themselves and families, many of whom would gladly attend evening classes for theoretical instruction, if accessible at reasonable cost. That this is true is proven by the large number of workmen in Europe and in sections of our own country who, of their own accord, attend evening classes when opened in technical schools, universities, etc. That many of these men and boys make commendable progress in their studies, even after working hard all day, is shown by the testimony of those having charge of such classes. Those of our colleges and universities having class-rooms, laboratories, apparatus and libraries already equipped could, generally, without great expense, make arrangements for evening classes. In Owens

Absence of evening schools.

College, Manchester, an institution of about the same rank as the Johns Hopkins University, several of the instructors of the day classes also give instruction to evening students, who number about six hundred. The class-rooms of the Polytechnic Institute at Regent Circus, London, are crowded to their utmost capacity every evening of the school year by young men and middle-aged mechanics who spend the day at work in shops. This school has accommodations for about three thousand students, and hundreds of applicants are refused admission every year because there is no room for them. Many who do gain admission to the classes succeed in passing the Government examination in science, or the city and guilds examination in technology. The fact that hundreds of workpeople in our own country avail themselves, with great profit, of the evening instruction afforded at Cooper Institute, New York [Exhibit L], and at the few other evening schools of merit in our cities, adds to the proof that there is a demand for increased facilities for practical instruction in evening classes.

Evening students in Owens College, London Polytechnic Institute, and Cooper Institute, of New York.

In a recent special and comprehensive report on the present status of industrial education in the United States —from which I have gained much information—the Commissioner of Education at Washington says:

"The manufacturer is aided by industrial education through the improvement of his products. His success depends on the demand for his goods at reasonable prices. This demand is regulated by the needs of customers. They ask for durability of material, attractiveness of design and excellence of workmanship in whatever they purchase for permanent use. Manufacturers' business improves as they become possessed of these and similar qualities, which can be economically secured only by the application of technical knowledge. Durability arises from excellence of raw material, and is retained by the selection of the right processes by which to convert it into the state in which it finally appears. The quality of raw material is not unfrequently to be determined by chemical tests, and many of the processes of its manufacture are regulated by chemical principles. The science which guides in the determination of these processes must be the one which will lead to their improvement and perfection. Hence courses in chemistry are established in our principal polytechnic schools, as well as in colleges of agriculture (to which science chemistry makes liberal contribution), and in

Views of Commissioner of Education, Washington, upon industrial education.

schools of mining and metallurgy. For a similar purpose engineers are taught to determine the strength of materials used in building railroads and bridges, houses and machines. Investigations in the domain of physics and chemistry have frequently taught the skillful application of new and serviceable agents to the production of labor. Men thus taught have laid out our railways, opened our mines, started and improved our manufactories and built our houses. They have aided in increasing our industries 35 per cent. in the last decade and in compelling an English confession that 'the United States will probably pass us in the ensuing decade' in the value of her industries.

"The elevation of the working classes is an inevitable result of educating them in industries. The direct effect upon the intellect is great and beneficial. The immediate moral influence is of the best. A manly feeling is awakened and kept alive by the consciousness of power and skill to do. An incentive to frugality and enterprise is set forth. It has been laid down as a rule by Prof. Edward Atkinson that—

"'Other things being equal, high wages, coupled with low cost, are the necessary result of the most intelligent application of machinery by the arts, provided the education of the operative keeps pace with the improvement of the machinery.'

"Industrial education dignifies labor as well as opens doors to its skillful and remunerative performance. If labor has a noble end and purpose; if it employs intellect; if it abundantly rewards its servants, then it is worthy to be crowned.

"The perfection of our manufactures, the facilitating of commerce, the unearthing of mineral wealth, the economizing of the fertility of farms, the dissemination of practical knowledge—these are ends which are being served by the graduates of our industrial institutions. These ends do not lack nobility. These forms of labor require the exercise of high intellectual powers. The attainments are of no mean order which enable a man to perform the great feats of engineering for which our country is becoming known, or which are required of superintendents of extensive factories. Even the doing of a single thing understandingly and well brings the doer respect from himself and his neighbor, and dignifies his calling. 'It is the privilege of any human work which is well done,' says Emerson, 'to invest the doer with a certain haughtiness. He can well afford not to conciliate whose faithful work will answer for him.'

"The diminution of crime is to be expected from the diffusion of industrial education. The percentage of criminals who have received even the elements of an education is small. An authority on the subject has said that 'one-third of all criminals are totally uneducated, and that four-fifths are practically uneducated.' Yet when the relative number of convicts who are illiterate is compared with the number of those who have not learned a trade, it is found to be much smaller. It is stated by Dr. Wines that in Baden only 4 per cent. of the prisoners are unable to read when received, and that they are for the most part fond of reading, but that 50 per cent. have not learned a trade; in Bavaria 12 per cent. are illiterate, 29 per cent. ignorant of a trade. Mr. Charles F. Thwing a few years since claimed that 60 per cent. of the inmates of the Michigan State Prison had no trade, while less than 25 per cent. could not read, write and cipher; that in the Prison of Minnesota 37 of 235 prisoners could not read and write, 130 never learned any business; and that in the Iowa Penitentiary the ratio of illiterate convicts to those unskilled in a trade was about 1 to 6.

"Whatever may be the reliability of these figures, it cannot be denied that the lack of technical training is a prolific cause of crime. This lack is being supplied to some extent by some recently established schools, which both afford opportunities for such training and draw public attention to the existing need of it.

"The introduction of industrial features into educational institutions has a tendency to relieve education of the accusation that it is unpractical. There are those that ask of our schools more than they are intended to furnish. Their

voice in years past called into being manual-labor and half-time schools. Since the failure of these means to realize the expectations of their advocates, believers in education for industrial labors have been uncertain what course to adopt in carrying out their views. Now, it may be said with safety that the mass of our citizens are convinced that the educational systems and institutions of the country are above reproach, and will be modified by the introduction of new features as they are needed. A minority are disposed to be critical and assert that education is unwisely conducted, and that governmental aid might be applied more reasonably to the establishment of public farms and workshops for training purposes than to public schools.

"Finally, protection to American institutions demands the industrial education of our youth, that they may carry our ideas of obedience to law and our republican principles into the midst of the multitude of foreigners that crowd our factories and our mines and perform much of our labor.

"Ours is a peculiar nation. In it the principles of morality prevailing in civilized countries are upheld with warmth and reason. Our political principles are distinctive and characteristic. Daniel Webster enumerated them in one of his great speeches. They are the establishment of popular government on the basis of representation; the recognition of the will of the majority, fairly expressed, as having the force of law; the supremacy of law as the rule of government for all, and the existence of written constitutions founded on the authority of the people. He asserted his belief that the influence of town meetings in which American principles were recognized and followed, made those who went from them to dig gold in California 'more fit to make a republican government than any body of men in Germany or Italy.' If there be added to the lessons of our political gatherings and elections education in the essentials of government, instruction in the sciences contributing to human prosperity, familiarity with the languages of civilization, sound rules for the conduct of life, and training for an ennobling and enriching occupation, then American youth will be prepared oftener to fill leading places in industries, will win respect for their skill, learning and wisdom, and, being respected and trusted, will be enabled to enshrine American liberty more securely in the hearts of laboring men. So our land shall be the home of a safe and permanent nation, 'where an industrious population advances like a victorious army, where the poor find work, the laborer becomes a proprietor, the proprietor grows rich, and all have the hope of a prosperous future,' and the ends of our industrial education will be accomplished."

Common sense and experience combine in declaring that, to attain to eminence in science, art or literature, nations and communities must make liberal provision for institutions devoted to their study and investigation. A rudimentary principle of political economy is that, in direct proportion as money is invested in the endowment of such institutions with free professorships and scholarships, and the means for original research and experimentation, is its value compounded by their rapid advancement in those branches of knowledge which are the foundation of national prosperity. In recognition of this principle, the several States of the Union have not been backward in endowing universities and colleges devoted to the study

and investigation of one or more special subjects, and the *natural increase* of those institutions is sure to provide for the maintenance and the reasonable advancement of our literary and abstruse scientific status among the nations. Let greater provision, therefore, be made for the practical application of scientific and technical knowledge to our useful arts and trades, which are languishing in every branch. Whatever the cause of this depression may be, improvement in the quality of our products would go far towards stimulating demand and in restoring prosperity, just as it has done abroad in less favored localities and under more adverse circumstances. Besides, there are numerous new industries awaiting development and the assistance which technical knowledge alone can give. Society tires of the old and a depression in business ensues; it clamors for the new and novel, in which, when produced, it is always ready to invest millions; thus affording employment to many workmen, the disbursement of whose earnings in sustenance, clothing and shelter for their families has a far-reaching effect in stimulating other industries. Witness the application of the recent discoveries and inventions in the domain of electricity.

Development of new industries.

It has been shown that, in Germany, France, Switzerland, Belgium, Holland, and, later, in England, the promotion of the useful arts is acknowledged to be of the first importance, as lying at the foundation of all industrial enterprises, and in all those countries many of their ablest citizens devote their lives and scientific knowledge to improving methods of manufacture and the attractiveness and utility of staple products; to the discovery of new designs and to the origination of new industries; while great polytechnic and less pretentious institutes exercise a healthy and stimulating influence in the same direction.

The useful arts the foundation of industrial enterprise.

A respectable class of our citizens, both young and old men of ability, devote themselves to a single branch or phase of literature, the ornamental arts and the pure sciences, while, considering the size and population of our country, the number who devote themselves from similar motives to *applied* science, technical arts and education—*i. e.*, not related to the social professions and fine arts—is really insignificant. When, in addition to some such plan as that outlined by Dr. Philbrick, our agricultural colleges are given the breadth, and are equally devoted to the several branches of instruction, intended by Congress; and when, by the rearrangement of present and the establishment of additional polytechnic schools, sufficient industrial instruction is afforded to meet even present needs and demands, the more important, at least, of our industrial trades will take their true positions as of equal respectability and value as the professions and the higher commercial pursuits, and then the (to us now utopian) condition will be fulfilled when our mechanics and artisans, like the peasants around Groningen, can cast "compassionate glances at all that population of shopkeepers, clerks, professors, officials and proprietors who, in other countries, are envied by those who till the ground, but here are regarded by them in the light of *poor people*."

More devotion to applied science and technical arts needed.

INDUSTRIAL AND EDUCATIONAL NEEDS OF BALTIMORE.

The foregoing statement of the development and present condition of technical education, abroad and in the United States, though only a brief and incomplete historical sketch, affords a basis for comparing Baltimore, commercially and mechanically, with other localities where higher scientific methods are practised in corresponding industries. Such a

Comparison of Baltimore with other localities.

comparison seems absolutely necessary to awaken an interest in, and a demand for, more thorough and widespread scientific knowledge, the power and effects of which, in the arts, manufactures and trades, are portrayed in the preceding pages of this report; for it is to be observed that where the lack of scientific instruction and technical training is greatest, the want of it is least likely to be felt by those who are deficient in it. Realization of the need is generally followed by sufficient agitation to secure it.

Baltimore not progressing.

It must be painfully apparent to a large number of our business men, as well as to other thoughtful citizens that, notwithstanding her superior natural and artificial advantages and resources, Baltimore is not only not progressing, as compared with even less favored sections, but is not maintaining her former position in the commercial and manufacturing world. Whatever the causes of the general apathy that is paralyzing her business enterprises may be, they must be analyzed, the facts brought to light and their effects understood, before intelligent measures can be devised for producing a different state of affairs. Although it is never an agreeable task to criticise, in any relation, the community in which one lives, yet here, as in surgery, the diseased part must be bared and its condition made manifest before proper remedial measures can be determined. The interests of our service are so interwoven with the commercial prosperity of Baltimore; the poverty of her youth in intellectual attainments and mechanical skill has been so painfully manifested in the preliminary examinations held the past year in connection with the technological classes at Mt. Clare, as well as in the current mechanical operations of the service that, in view of the intimate relations that must always exist between the educational facilities of the city and any technological institution that

Causes must be understood.

Not an agreeable task to criticise.

Reasons for discussing the industrial and educational needs of Baltimore.

may be established within or near its boundaries, a discussion, in this report, of the needs of the city in the matter of technical instruction and its advantages, becomes pertinent—indeed necessary. Neither from professional education nor experience am I able to treat the subject exhaustively. But what is hereinafter cited is patent even to superficial observation, and if, through this citation, such general interest can be awakened in Baltimore as shall result in placing her industrial and technical educational facilities—which are of paramount importance to her prosperity—upon a par with those offered by rival cities, a great boon will have been conferred upon the community in general, and the Baltimore and Ohio Railroad Company and all our other manufacturing corporations will enjoy the reflex advantages accruing from the increased intelligence and skill that her working-people will soon acquire.

If those public-spirited citizens who recognize our deficiencies in this respect, and whose professional or business attainments place their qualifications and motives beyond cavil, can be induced to unite in devising and in securing the acceptance of an intelligent and practical measure for reviving and extending the industrial interests of the city, its commercial and manufacturing advantages are unquestionably such that it would soon not only recover its lost prestige, but would rapidly advance beyond the prosperity of many of its now successful competitors. At this time there are indications of the birth of a new South—a South that shall become famous and wealthy, through the development of its immense resources and the application to its industries of scientific methods, which elsewhere will be of slower growth, because they will supplant and make worthless the expensive plants of present processes.

Necessity of united effort to restore prosperity.

Indications of a new South.

Approaching era of national prosperity.

Standing as we evidently are at the threshold of another era of national prosperity, in which the South and other sections naturally dependent upon Baltimore (as the connecting link between the North and South) for manufactured products must participate, the present is an opportune time to make provision for industrial education commensurate with the needs and resources of the city.

The causes that have combined to relegate Baltimore to a rank so far beneath her true status as a commercial and manufacturing centre become readily apparent from a study of her industrial history. It is unnecessary to enumerate them here, but it is pertinent to remark the almost invariable lack of appreciation, at times actually assuming an attitude of unreasoning antagonism, with which the efforts of those who have sought to promote her material prosperity have been received. Considering the widely divergent and irreconcilable views developed upon the presentation of many plans from time to time devised for the improvement of her trade and commercial relations, it is manifestly useless to hope now for fruitful result from any similar proposition which has not the merit of promoting at least the principal business interests of the city.

Methods heretofore proposed to secure prosperity have not met with general favor.

Municipal industrial education, however, offers a program upon which every business interest may harmonize, with equal certainty of sharing in the ultimate prosperity which, as experience has shown, uniformly follows its general adoption in a trade centre, and which it can hardly be questioned would, in the case of Baltimore, prove equally —and probably far more—valuable than could reasonably be hoped for from any of the measures for increasing our general prosperity to which allusion has been made; while at the same time promoting the material, intellectual, and moral welfare of the masses of our population.

All interests may profit by technical training.

Historical retrospect of Baltimore.

During the period between the close of the Revolutionary War and the War of 1812, the city of Baltimore enjoyed its greatest prosperity, and at the end of the latter conflict it gave promise of becoming pre-eminent among the most prosperous commercial and manufacturing cities of the country. It was then that its growth was most rapid; new enterprises were readily undertaken, and its commerce was, relatively, if not actually, greater than ever since. After the opening of the Erie Canal, its most astute business men, realizing that without more rapid and direct freight communication with the west, Baltimore must suffer greatly from the increased competing power of New York, as early as 1820 began an agitation for increased traffic facilities to the west, the outgrowth of which was the organization of the Baltimore and Ohio Railroad Company. Though constantly subjected to the attacks of rival corporations, to home opposition born of prejudice and jealousy, and to the more vexatious indifference with which its efforts to maintain and stimulate languishing industries have been met by those it sought to benefit, the Baltimore and Ohio Railroad Company is to be credited with diligent and consistent efforts to foster and enlarge Baltimore manufactures and commerce, and it is interesting to observe that, to the extent it and its affiliated interests have been conducted in a liberal and progressive spirit, they have expanded and prospered amid a general decadence of the city's industries.

Organization of B. & O. Company.

Superior natural advantages and resources of Baltimore.

While substantially at its door are water powers capable of furnishing motive force for many times its present manufactures; while the advantages of its superior geographical relation to a large and productive section of country are preserved by its being the terminus of an extensive trunk-line system tapping that section at many points; and while

it has within easy reach enormous reservoirs of the finest steam-making coals found in America, as well as generous supplies of iron, copper, hard woods, cotton, tobacco, and other material suitable for manufactures—in fact, all the staple raw materials, the conversion of which into manufactured products builds up those large industries and commercial interests without which no city can be great or prosperous—Baltimore has practically lost all claim to pre-eminence or even prominence in any manufacturing or mercantile pursuit. Not only do many industries developed elsewhere, and which should be prospering here, not exist, but it has been impossible to maintain those we had, and yet the apathy of the community is such that no substantial response is made to the most urgent appeals for financial encouragement and assistance in increasing our commerce, reviving old or establishing new manufactures or kindred enterprises.

Loss of prominence in industry and commerce.

To be more specific, I may remind you that Baltimore has, apparently through pure lack of energy, lost the West India sugar trade, and her iron industries are little short of the throes of dissolution. The gravity of the loss of this sugar trade is shown in a recent pamphlet prepared under the instructions of Mr. C. Morton Stewart, which sets forth the total value of the city's imports of sugar and molasses in 1874 as $10,598,227; decreased in 1884 to $107,041, but even these figures by no means represent the net loss to the city, in one decade, from this single item—the ten millions of imports merely representing the *raw material brought here;* to which should be added the commerce supported by its transportation, the repairs to vessels, the labor and the manufacturing industries incident thereto; all of which, when summed up, show a loss much more serious and far-reaching than that indicated by these bare figures.

Loss of West India sugar trade.

Extent of this loss.

How to regain this trade.

Were Baltimore now able to manufacture those articles for which West Indian products are exchanged, at prices and of quality that would compare favorably with the wares of rival manufacturers, thus directly exchanging manufactured goods at a profit for those products, instead of paying for them in specie and compelling incoming vessels to look elsewhere for return cargoes, we could, in a large measure, again attract this lucrative trade to our port.

Diminished maritime commerce.

Baltimore has entirely lost her reputation and renown in maritime pursuits, which at the close of the war of 1812 was world-wide, without gaining compensating advantages. Possessing a fine harbor and first-class shipbuilding facilities (including a dry-dock hardly surpassed in size and equipment by any other on our coast), she is yet debarred, through the unskillful work of her artisans, their trade agitations and prohibitory labor tariffs, from securing the construction of even the few coasting steamers registering at her port, while her shipbuilders are, from the same causes, compelled to decline bidding on the few ocean bottoms offering for construction here. The Abbott Iron Works, after a prosperous business career, have been idle for a long time, and are now about being sold and the valuable plant thereof distributed. The same general cause accounts for the depression in other branches of trade, with the details of which all citizens who, like yourself, take an active interest in the welfare of the city, must be familiar.

Abbott Iron Works.

But it is unnecessary to multiply illustrations of neglected opportunities for enhancing our wealth and increasing our corporate and commercial importance, or of absolute loss of established trade, apparently from a species of dry-rot, incomprehensible, but very satisfactory to our more pushing rivals; for no one better than yourself appreciates the

great disadvantages under which Baltimore now labors in her competition with other cities. It is sufficient for the purposes of this report to point out that, because of the city's commercial apathy, the Baltimore and Ohio Railroad Company has frequently been compelled to hazard, and more than once to sacrifice its revenues, in order to prevent the practical suppression of the trade of the port, in which the business interests of the city are common with its own.

B. & O. revenues often hazarded and sometimes sacrificed to protect the city's industries and commerce.

To cite recent examples of this, you will remember that when, less than a year ago, the Baltimore emigrant business was threatened by her Northern rivals, the Baltimore and Ohio Railroad Company found it necessary to surrender the profit of the business in order to secure the maintenance of the few steamship lines running to this port.

Examples of this.

Also, that though many attempts have been made to retain our coasting trade, such was their lethargy, that it was very lately found impossible to induce our merchants to subscribe sufficient money to insure even a line of steamers between Baltimore and Charleston.

Probably I cannot more forcibly illustrate our city's poverty in respect to business enterprises generally, and to manufactures specifically, than by quoting at some length from the Report of the Commission on the Establishment of Manufactures, made to the Mayor and City Council of Baltimore in 1877, which contains much valuable information on the subject of which it treats, but which seems to have received much less consideration than its merits deserve. From p. 20 *et seq.* are extracted the following quotations:

Industrial poverty of Baltimore as shown by Report of Committee on Establishment of Manufactures.

> These tables, which have been very carefully prepared, disclose the poverty of Baltimore as a manufacturing city with painful distinctness. Baltimore is (by Table B) shown to be far below the industrial average in the proportion of

her workingmen to the entire population. There is one operative in every 5.2 persons in Wilmington; 1 in every 5.04 in Philadelphia; 1 in every 5.5 in Boston; 1 in every 5.8 in Cincinnati; 1 in every 3.6 in Newark, New Jersey; 1 in every 7.6 in St. Louis, while Baltimore has only 1 in every 8.1.

This deficiency of manufacturing hands is more than accounted for by a still greater deficiency of capital per capita invested in industrial pursuits. In this respect Baltimore ranks the lowest of any of our large cities—lower even than Louisville, Kentucky. In Philadelphia the capital in manufactories is $252 per capita; in Wilmington $235; in St. Louis $194; in Cincinnati $197; in Boston $188, while in Baltimore there is only $97 capital per capita so invested—less than half as much as Cincinnati has; just half as much as St. Louis has; only a little over half as much as Boston has, and not a great deal more than a third as much as there is in Wilmington and Philadelphia. The tables of bank capital and savings-bank stock and capital will show that in Philadelphia, Cincinnati, St. Louis and Chicago, the money which our citizens lock up in bank stock, ground rents, private discount banks and such securities, is by preference invested in productive industrial enterprises. In those cities, as the tables show, capital is used to buy materials and pay wages, and returns in the shape of values received for products manufactured. In Baltimore, on the other hand, capital is used to produce interest. While in neither case can it be truly said that capital is barren (since the hiring of money may be as useful as the hiring of sewing-machines or any other sort of tool or service), yet it is quite apparent that money used in manufactures and other forms of active production is more fertile than money put at interest, or in ground rents or land, to reappear in permanent improvements distributed over a period of years, or in houses and buildings. Capital in manufactures must turn itself over at least once a year, and it will be seen by comparing the column of capital (Table B) with the column of "materials," that more than the total capital of all manufacturing establishments is every year invested in the purchase of raw materials for manufacturing, and more than a third of the whole capital of such establishments is annually disbursed as wages.

Wages added to cost of material and the sum deducted from gross product gives gross profits of manufacture, expenses of course not being allowed for. Tested by this, we find that in Philadelphia manufactures in 1870 paid 47 per cent. on nominal capital, in Cincinnati 43 per cent., in San Francisco 47 per cent., in Baltimore 48 per cent., in Chicago 50 per cent.. in Louisville 50 per cent., in Boston 61 per cent., in Wilmington 71 per cent., in New York 74 per cent., and in St. Louis 120 per cent. Unquestionably, these figures show an excess of capital to product in Philadelphia and Cincinnati, and a deficiency of capital to product in St. Louis, but they also show that manufactures are less profitable in Baltimore than elsewhere, when we come to deduct the heavy taxation and other charges to which they are subject here, and from which they are free in Philadelphia.

If now we turn to Table A, we will find our deficiencies set out in detail in comparison with smaller cities, and with rival and competing ones. Your commission do not need to do more than call the attention of your honorable body to the array of facts presented in this table, showing how we are surpassed, even in manufactures which we ought to monopolize, by the most inferior towns and cities. There is only one particular in regard to which your commission will dwell upon in the figures in this table, and that is in respect of the manufactures which are needed to keep up our mercantile business and domestic commerce with the South and with our own counties. In the item of agricultural implements, for instance, Chicago makes seven times as many, St. Louis five times, and Louisville three times as many as we do. In the item of fertilizers we are surpassed by Wilmington, not to speak at all of other and larger places. In the item of boots and shoes, leaving all New England out of the question, Philadelphia makes four times as many, and St. Louis, Newark and Chicago, all three, equal our production. Chicago manufactures more than four times as

many bricks as we do, in spite of our facilities. In the making of carriages, etc., Cincinnati manufactures more than four times as much as we do, New Haven six times, and Wilmington and Chicago three times as much. In confectionery, while no city can rival Philadelphia, Chicago makes three times as much as Baltimore. Our cotton manufactures are not yet quite on a level with those of New London. In flour and meal Newark, Wilmington and Louisville are our equals, while Chicago makes three times and St. Louis fourteen times as much as we do. Chicago and Louisville beat us in furniture. The glass manufacture of Pittsburgh is fifty times as great as ours. In iron manufactures, leaving out the great centres of this industry, we find ourselves inferior to Chicago, and not much above Louisville, Newark, New Haven and Wilmington. In leather manufactures we are completely outstripped by all the large cities, by every city in the country, in fact, which has half our population. In liquors, distilled or malt, even Newark surpasses us. In machinery we are not equal even to small cities like Newark, New Haven, New London, Louisville, Wilmington, etc. In sugar refining, leaving out Boston, New York, Brooklyn and Philadelphia, we find St. Louis beginning to be our rival. Of paints we manufacture $400,000 worth; St. Louis $2,000,000. St. Louis makes ten times as much patent medicine, ten times as much saddlery and harness, ten times as much manufactured tobacco, as Baltimore; while Cincinnati makes twenty times as much soap and candles, and St. Louis four times as much as we do. In stoneware we make $127,000; Cincinnati $3,600,000. In sash manufacturing our products are a beggarly $145,000, against $2,300,000 for St. Louis, $800,000 for Newark, $500,000 for New Haven, $250,000 for Wilmington, etc. In short, the exhibition is in the highest degree painful and mortifying, and must cause serious apprehensions in the minds of all persons who know that it takes trade to make trade.

It will not be denied that this is an anomalous condition of things. Equally it will not be denied that manufactures bring wealth and population to cities in more certain and speedy ways than any other form of labor.

As Amasa Walker said upon this point: "It is without question true that in an equal manufacturing population will be found a greater accumulation of wealth than in an agricultural or commercial population. One important reason of this is that a larger share of the population are engaged in production, and a larger amount of capital is employed. Women and children, who could earn but little in agricultural labor (and none in commercial), can earn much in manufacturing. Manufacturing need never stop, summer or winter, cold or hot, wet or dry."

Baltimore cannot escape competition.

These facts are not pleasant to contemplate, but they must be faced whenever an earnest effort is to be made to increase the prosperity of Baltimore, be the time present or distant. It is idle to expect to escape competition with other cities, and equally idle to expect success therein under existing circumstances, or to depend for municipal growth upon sporadic seasons of national or local prosperity; for in these days of rapid travel, cheap and quick transportation, those centres best equipped with plant and skilled workmen will inevitably, in seasons of prosperity, substantially absorb the profits of quickened trade. In

the United States seasons of great prosperity are succeeded by periods of stagnation of trade, which subject our institutions to great strain. During these recurring periods of business depression, and because of the dearth of staple and diversified industries of magnitude, Baltimore suffers disproportionately to other centres of trade. I am told that this strain was particularly severe when, during the labor disturbances of 1877, traffic was interrupted on her principal remaining element of commercial prosperity—the Baltimore and Ohio trunk-line system. Had the earning capacity of the city accrued, in any material degree, from manufacturing industry, the depression would not have been so great.

Baltimore suffers unduly in periods of business depression.

Mr. Mather, in commenting on the industry of our city, says: "Baltimore does not possess any large distinctive manufactures; her trade is chiefly that of grain and timber export." Though a mere statement of fact, this quotation contains a reproach to our city, whose great opportunity is that of distinctive manufactures, and whose great want is an increase of productive capacity. It cannot be too often reiterated that we need greater industrial activity to afford employment to our citizens, to add to the value of our property, to increase municipal income, and to attract capital and men of business to our city. But at this time to what industry can our people point as, in a visible degree, drawing foreign population for permanent residence within the limits of their city? Or what inducement do they hold out to capitalists to bring wealth from other localities and settle here with a view to engaging in industrial pursuits? Our own citizens are phenomenally backward in investing in extended business enterprises, and in the absence of special inducements it is useless to expect aid from foreign business men or capital. Commercially

Mr. Mather comments on Baltimore's trade deficiencies.

Imperative need of greater industrial activity.

our city will remain nothing more than a second or third-rate exporter of raw material until, within its corporate limits, this raw material is converted into manufactured products.

Some cities depend for their prosperity upon the manufacture of special products, as witness Manchester, which so long enjoyed pre-eminence through its cotton textile fabrics, though it imported all the constituents thereof; Crefeld, a wealthy Prussian city, which depends for its prosperity almost exclusively upon its silk manufactures; Sheffield upon its cutlery, and Lynn, Mass., upon its manufactured products of leather. But, as has been said, Baltimore can boast of no distinctive manufactures. Our only hope of industrial prominence lies in the inauguration of a multiplicity of varied industries.

Baltimore cannot depend upon distinctive manufactures.

There is abundant testimony to show that a city's prosperity may result from a great demand for some local natural production, or even from limited markets where there is no competition. Of this we have an example in the city of Pittsburgh, whose wealth is dependent upon the iron and coal trade; as also in the oyster trade, of which Baltimore for many years enjoyed a substantial monopoly, and which is still of sufficient magnitude and financial importance to count as a chief element in the city's prosperity. But this oyster trade can by no means provide support for our large population, and even respecting our oysters it is to be remarked, parenthetically, that for want of care, proper legislation and development, the beds of the Chesapeake are rapidly decreasing in yield, and already the oyster industry of Long Island Sound has become an active and powerful competitor of, and bids fair to eclipse, our home trade. Unless, therefore, efficient means are speedily taken to replenish our waters,

Baltimore's oyster industry declining.

the time must soon come when "Baltimore oysters" will be as rare as "Baltimore clippers."

In times past, a city like Baltimore, possessing within its boundaries (or by reason of cheap transportation, or favorable location, holding tributary to it) abundance of cheap raw materials might, if it possessed, additionally, facilities for cheap manufacture, successfully compete with less favored rivals, without much regard to the quality and finish of manufactured products. But in these days, when rival transportation lines distribute crude materials to competing points upon substantially equal terms, with little regard to long or short hauls, and when the cultivated tastes and luxurious habits which result from increased wealth create an active demand for superior quality and finest finish, such centres as are best prepared to turn out first-class articles will control the market. It is just here that educated and skilled labor becomes a factor of the greatest potency, because, as has been shown in the first two sections of this report, while improving quality, it uniformly cheapens production to such an extent that the control of such labor has enabled many cities to overwhelm trade competitors who possessed cheaper raw material or better natural facilities. That we are totally unprepared to avail of any artificial means of bettering our condition is patent from the Report of 1877 already referred to, which in very strong terms sets forth our deficiency in regard to manufactures. However great the national and foreign demand for manufactured products might be, were all other factors present, the dearth of skilled and trained laborers in Baltimore is so great that it could not, to-day, compete with other cities in the manufacture of special—and not even of many staple—products.

Abundance of raw material and cheap manufacture no longer insure successful competition.

Potency of educated and skilled labor.

Low rents and taxes and favorable laws have very great attractions for capital, and hence many towns, without

Low rents and taxes considered.

possessing any special natural advantages, have received the impetus which resulted in their becoming large manufacturing centres purely as the result of a liberal municipal policy. But while exemption from taxation and other special privileges are influential in building up new and reviving and extending old enterprises, by inducing the investment of capital, yet, in the present era of active competition and small profits, a factor more important to their permanency *is the assurance of skilled and intelligent labor*, an abundance of which has been shown to attract capital far more than the other advantages enumerated. Comparison between Philadelphia and Baltimore aptly illustrates this. For commercial purposes no better, and for manufacturing purposes not so advantageously, situated as Baltimore, Philadelphia, first by offering special exemptions from taxation and other inducements for the investment of capital in manufacturing works and, later, by the establishment of such technical and industrial schools as the Mechanics' Institute, Spring Garden Institute, Franklin Institute, the Philadelphia School of Design, the Pennsylvania School of Fine Arts, the Pennsylvania Museum and School of Industrial Art, the Mechanical Department of Pennsylvania State College, Girard College, and the Philadelphia Manual Training School, has grown into and maintains its position as the second city in the Union, and as pre-eminent in its manufacturing and allied industries; while Baltimore, practically without technical institutions, except the meagre facilities of the Maryland Institute, and until lately with onerous and unusual taxation, has, as stated by the city's commissioners on the establishment of manufactures, substantially starved out its old, and prohibited the undertaking of new, manufacturing enterprises. We may deepen our harbor and make

Comparison between Baltimore and Philadelphia as manufacturing centres.

Facilities for technical training in Philadelphia.

Baltimore practically without technical institutions.

valuable additions to our natural and artificial facilities for trade and commerce, but, as Mayor Latrobe aptly remarked in his message (1877), "We should remember that it is not commerce alone, but commerce and manufactures together, which will insure the future prosperity of the community."

Baltimore's backwardness results from insufficient technical education.

Comparison between the present condition of Baltimore and the industrial status of many European cities that have experienced its vicissitudes only goes to corroborate the conclusion herein announced—that the backwardness of the former results from the insufficient technical education of our artisans and laborers. [Exhibits D, E and F.] Neither our immense resources in the shape of raw materials, our facilities for manufacture, our advantages in the way of cheap living and healthful climate, nor the offering of low taxes and rent, nor all these combined will effect, at this late date and under existing conditions of trade, the restoration of Baltimore to its normal position among the industrial and commercial centres of the country. But if we crown all these advantages with that most potent of all agencies for promoting industrial prosperity, a combination of superior skill and intelligence on the part of our managers and workpeople, we may then hope to stimulate new business ventures and to see Baltimore once more taking rank with the first cities of the nation. It is very generally conceded that no enterprise turning out products for sale can successfully compete in our own and foreign markets unless superior skill and intelligence can be secured to conduct it. Certainly then it is only reasonable to suppose that if special schools are essential to success in any industry, men who desire to engage in that business would rather go to a city where such schools are already provided than to a city like Baltimore, where, before they can hope for success, they must be at the expense and trouble of estab-

New industrial enterprises will go where technical training is provided.

lishing or helping to establish technical schools. We have an abundance of crude labor, as well as of cheap and crude material; but preliminarily to converting that material into attractive and useful products we must so train our artisans as to make them at least the peers of foreign and home workmen following kindred pursuits. Then, when men of means and enterprise realize that we offer them not only raw materials and the same concessions and liberal policy that have proven so successful in promoting the corporate prosperity of Philadelphia and other cities, but likewise the necessary skill and intelligence to transform those materials into marketable commodities, we may reasonably count upon the assistance of outside capital in starting a host of manufacturing and kindred enterprises.

Abundance of raw material tributary to Baltimore.

In every field where American enterprise has entered, it has asserted itself and has been fully recognized—especially in labor-saving inventions for agricultural purposes. What has been accomplished in agricultural machinery can be done in metallurgy, textile fabrics, wood-work, railway appliances, etc. Nowhere are there cheaper or more extensive deposits of minerals, timber and other raw material than in the vast mountainous regions of Maryland, Virginia and West Virginia, tributary to this city. Ample capital is seeking investment in any business in which profit is reasonably certain; machinery embodying the latest designs of the inventor's skill can be procured; markets are accessible; what is needed is skilled and educated laborers to direct and carry on the industries which convert raw material into manufactured products. But skilled and intelligent workmen are not found to hand; they must be made.

Capital seeking investment.

The foregoing may appear to be trite remarks, more suitable for trade reports or the proceedings of civic banquets than for embodiment in a report of this character,

valuable additions to our natural and artificial facilities for trade and commerce, but, as Mayor Latrobe aptly remarked in his message (1877), "We should remember that it is not commerce alone, but commerce and manufactures together, which will insure the future prosperity of the community."

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New industrial enterprises will go where technical training is provided.

The remedy to be found in technical training.

As one of the first steps toward securing much-needed additional facilities for the technical training of Baltimore's youth, there should be radical changes in the present methods and character of public instruction. I fully recognize how much easier it is to point out errors of administration than to suggest wise remedial measures,

Difficulty of suggesting wise remedial measures.

and how unbecoming it would be in any one to make such suggestions without special preparation and recognized fitness for the task. To change the character of public instruction in a great city like Baltimore is a very serious undertaking, and no proposition contemplating such action should receive serious public consideration unless sustained by irrefutable facts and arguments. But while I conceive it to be altogether outside my duty, even on behalf of the material interests of our service, to propose lines for

Reasons for considering the educational facilities of Baltimore.

municipal policy, and while I believe your instructions will have been measurably executed when I shall have given you a clear idea of the character, extent and effects, in general, of technical training, and specifically of the beneficial results that may, with reasonable certainty, be counted upon to follow the inauguration of technological instruction in the Baltimore and Ohio service, I also feel that the character of tuition under the public-school system of Baltimore and the State of Maryland is of as paramount importance to any technological work at Mt. Clare as is the commercial prosperity of the city to the revenues of the Baltimore and Ohio Railroad Company. If, in order to secure in its staff and in the rank and file of its service the same (if no greater) skill, intelligence and consequent efficiency that our Northern and Western rivals enjoy, the Baltimore and Ohio Company is unable in the future, as during the past year, to procure from the great mass of population in Baltimore enough candidates

for apprenticeship possessing the minimum elements of a grammar-school education to meet the requirements of the service, but must undergo the additional expense and labor of instructing its apprentices in those rudiments of English education which are absolutely essential as the groundwork for even the most superficial technical training, it will be well to consider whether economy and the best interests of the service will be promoted by continuing Mt. Clare as a construction station; and whether greater economy and more satisfactory plant will not be secured by distributing its machinery among the company's repair shops, and depending for articles now manufactured at Mt. Clare upon those outside works which—by reason of their employes having acquired a higher knowledge of the scientific laws that underlie their trades, and greater skill and higher intelligence than prevail among the artisans of Baltimore—turn out with economy the highest grade of such products as we now manufacture.

City school statistics.

It would seem that, in view of our large expenditure for free public schools, there should be no difficulty in securing educated boys for apprentices. The appropriations for the public schools of Baltimore aggregate about three-fourths of a million dollars annually, out of which nine hundred and sixty-three teachers are employed to conduct the schools. The estimated population of Baltimore at the present time is 400,000. The number of children and young people of school age (between 6 and 21) at the last enumeration in 1879 was 86,961 (it is now probably 100,000), of whom 52,970 were enrolled in the public schools in the year 1885–6, and the average daily attendance was 34,217. There are no statistics showing the number in attendance at the various private schools in the city. Of the 100,000 children and young people who

ought to be in school, perhaps 95 per cent. of the males, and a large proportion of the females are destined to gain their own livelihood—a majority in the trades and manufactures—and many must, wholly or in part, contribute to the support of others. The overshadowing importance of so shaping our system of education as to convert this great army of future citizens into intelligent and law-abiding men and women, who shall be able to maintain their self-respect by at least providing for their own wants, induces me, not only on account of the needs of our own service, but also from a consideration of the future well-being of the laboring masses and of the city of Baltimore, to unite with General Counsel Cowen in invoking your active efforts, "both as an officer and a citizen," in solving the important question how best to afford our working-people that character and quality of knowledge and training which will qualify them for conducting successfully the occupations of industrial life as they exist to-day, and which all interests, individual, corporate, municipal and national, alike require they should enjoy. In view of the peculiar identification that exists between Baltimore's political and educational systems, it is apparent that, to secure any substantial or valuable change in existing methods of education, will require the active countenance and support—without respect to political bias—of our entire business community, as well as of all other citizens of responsibility possessing knowledge of the conditions and needs of the city. Already many intelligent working-people are beginning to realize that if any improvement is to be made in their material condition, it will be through the proper education of their children in industrial occupations, and that therein, far more than in the false movements and agitations of trades unions, lie those elements which,

Necessity of adapting education to wants of the people.

Necessity of united action in bringing about needed changes in public instruction.

properly fostered, will insure the permanent betterment of their condition. It has been wisely said that "from domestic economy rather than from political economy will come the solution of the labor question." In thrift and industry, and in recognition, on the part of employers, of the justice and necessity of encouraging, in a practical way, all legitimate efforts of workpeople to improve their condition, surely lies the true solution of the great problem of labor *versus* capital; for you will have observed, from the historical sketch constituting the first part of this report, that in those localities where industrial education and technical training have been most promoted by employers, there, also, are the least friction and the least agitation of the complex and vexed questions constantly arising elsewhere between employer and employe. In this connection, I extract from the September number of the *New Princeton Review*, for the current year, the following citation from the proceedings of a New England Workingmen's Club:

Both labor and capital may profit by the right kind of education.

"We have examined the reports of attendance, and the courses of study, of many of the public schools in manufacturing towns in various parts of the country, and the impression made upon our minds is that the arrangement of studies is, in the main, adapted to the wants of pupils who take the full public-school, or high-school, course, so as to be prepared, or nearly prepared, to enter college.

Views of a New England Workingmen's Club upon the education of workingmen's children.

We also find, by extended inquiry, that a large proportion of the children of laborers, especially in manufacturing and mining communities, leave school finally before they are fourteen years of age. It appears to us that the education of these children is, usually, peculiarly inefficient, and, as a preparation for practical life, of little utility, from the fact that they have been employed mostly in *beginnings* in various branches of knowledge, and have acquired but little that is complete in itself. The studies for pupils under fourteen years of age seem to be, in great measure, only a preparation for the work of the more advanced classes, and they are therefore of uncertain value to those who must leave school at the age mentioned.

We recommend that the club invite the co-operation of workingmen who are interested in education in the effort to arrive at some practical conclusion regarding the particular education which working-people need—the kind of knowledge or training which can be obtained at school which will be of most worth to them in mature life—and we suggest that it would be well to obtain and compare opinions as to a course of study, or different special courses of study, for boys and girls who must leave school at fourteen years of age.

We will add that it appears to us that such inquiries will be more likely to yield valuable practical results if some division is made of the subject of education, than if it is taken up as a whole, or in an abstract or general way. The following is suggested:

1. It is desirable that the children of working-people should obtain at school knowledge and training which shall be, in some measure, complete in itself and available for use in after years regarding means and methods for the preservation of their bodily health. That is, they should receive specific instruction as to healthful ways of living, and in the care of their eyes, teeth, digestive organs, and other bodily faculties. The ordinary methods of teaching physiology in schools seem to us rather vague and ineffective, and, at any rate, not suited to the needs of the class of pupils we now have in mind. They should be taught the value of pure air and of pure water, and of some measure of out-of-door enjoyment, in relation to health of body and mind.

2. Laborers of all classes need far greater readiness in "the use of figures," in ordinary business operations with numbers, than is usually attained, even by the advanced pupils of our public schools. Our children should be trained to thorough efficiency in the use of the tables and rules used in measuring or ascertaining quantities of all kinds in actual business, such as brick-work, stone-work, and everything connected with building operations; in the measurement of articles of merchandise, of surfaces and solids of various kinds, and in the methods of computation for interest, percentage, etc.

3. They should be taught whatever will be in the greatest degree serviceable in enabling them to make life interesting for themselves and for those about them, and should be early taught that they must depend mostly upon themselves for this object. As one of the best means to this end, they should be taught to understand, enjoy and respect the powers of the English language, and should be trained to speak and write it with directness and sincerity, so that while they subsist by the labor of their hands, the life of working-people may be made attractive and interesting to themselves by thought. We believe that the inefficiency of education, and the vagueness and uncertainty of thought or mental vision which it produces, are highly injurious to the interests of the working-people of our country."

Scope and methods of our school system.

In order to suggest intelligent direction for your efforts and those of other public-spirited citizens whose active occupations and pursuits forbid their giving this subject the close investigation and thought its importance and great scope demand, it is proper briefly to enumerate the proposed objects and methods of our school system, as at present conducted, and then invite attention to the views of those best qualified to make suggestions and recommendations for improving our present method of public instruction "in the interest of those working-people of limited means who wish their children to look forward to manual labor as the means by which they are to obtain a livelihood," and fitting it to the industrial conditions that must exist hereafter. It will be sufficient for this purpose and will prevent unnecessary enlargement of this report to review, very cursorily, the educational facilities and

institutions of Baltimore; the character of instruction afforded and its bearing upon the industries that it seems essential to our interests to improve and promote—referring you to our annual school and other municipal reports for more detailed information.

First and most important among our educational institutions stands the system of public schools. These comprise primary grades, enrolling last year 24,511 pupils; grammar grades, enrolling 13,381 pupils; city high schools, enrolling 1163 girls; the City College, enrolling 630 boys; the Manual Training School, enrolling 120 boys. [Report of Commissioner of Public Schools, page 56.] Enrollment in the public schools.

The subjects taught in the primary grades are reading, spelling, elements of arithmetic, penmanship, drawing, and vocal music. The same studies, with geography added, are pursued in the grammar grade, which requires five years for completion, and physiology, history, grammar and composition, algebra, geometry, and elementary physics, are begun toward the close of the grammar course. Subjects taught.

The subjects taught in the City College, in addition to the common English branches, are English history, book-keeping, chemistry, natural philosophy, Latin, Greek, French, German, literature, algebra, geometry, trigonometry, calculus, astronomy, mental and moral philosophy, logic, and Constitution of the United States. City College.

The advanced studies in the girls' high schools are elocution, French, physiology, etymology, music, algebra, drawing, literature, rhetoric, natural philosophy, geometry, history of United States, mental philosophy, book-keeping, and astronomy. Girls' high schools.

The other public and endowed institutions accessible to residents of Baltimore are the McDonogh Institute, with a capacity for about 100 pupils; the Maryland Institute, Other public and endowed schools in Baltimore.

with very inadequate accommodations for perhaps 500 or 600 students; the University of Maryland, for students of law and medicine; the State normal school and colored normal school for training teachers; and the Johns Hopkins University, which affords higher instruction to such students from different parts of the world as possess the high standard of qualifications necessary for admission to its classes.

Schools affording instruction in art and applied science.

With the exception of drawing in the public schools, but little is taught that serves to fit pupils for industrial handiwork. Of the schools professing to teach, in a practical way, the science and arts underlying the industries of this country, there are only the Maryland Institute, the Manual Training School, and the McDonogh School. The first of these has to do with the arts and with drawing, while only the latter two pretend to teach applied science; and together, they afford instruction to fewer than three hundred boys, many of whom are in these schools for only a secondary purpose, expecting, ultimately, to become clerks, shopkeepers, or professional men.

Evening instruction.

At the present time in the city of Baltimore almost nothing is being done in the way of affording evening instruction to young people who are engaged in labor during the day. The attempts that have been made towards doing something in this direction by the public schools have not been very successful. No doubt one of the principal reasons of the failure is that the instruction offered to boys and girls has not been sufficiently practical to induce them to put forth the exertion required to enable them to profit by it.

Baltimore's limited facilities for practical training.

From these scanty statistics and citations it is readily seen that only a few schools, with very limited capacity

and insignificant financial support, can be classed as affording our working population a knowledge of the sciences as applied in industrial pursuits, and, therefore, the members of this large class necessarily enter the usual occupations of life untaught in technical knowledge and untrained in manual skill. Lacking the technical knowledge and the manual training to perform intelligently and skillfully the operations of the manufactures and other kinds of industrial work they expect to pursue all their lives, they must waste years that should be devoted to school or to earning wages, in acquiring sufficient manual dexterity to make their services valuable even in this market, and in doing this they forget much of the temporary information acquired at school. Manifestly, therefore, in order to supply the missing link in our public-school system, something must be done to provide facilities for imparting information and affording training of a character that will fit the workingman's children for acquiring such scientific knowledge as can be utilized in their various occupations. Of the $715,362 appropriated by the city of Baltimore for public-school instruction for the year 1885, only $12,800 or 1¾ per cent. was devoted to conducting the Manual Training School, and this is the only purely industrial institute provided for under our public-school system. The remainder of this very large sum is divided into sub-appropriations for the several grades devoted mostly to literary training. Included in this general sum is $6000 for conducting evening schools, which, however, are devoted entirely to the common English branches. While only $12,800 is devoted to special industrial education, about $75,000—or more than 10 per cent. of the school appropriation—is annually expended in maintaining two high schools and the City College, which do little toward fitting their pupils (about 1800 or less than 4 per

Disposition of school funds.

cent. of the enrollment) for handicrafts—their curricula being intended to qualify pupils for clerkships and the learned professions.

The claims for special industrial school facilities are equally as strong as the claims for special literary training.

As the Johns Hopkins University is exclusively devoted to higher education; as the Maryland Agricultural College is practically a cipher in affording technical training; as the Manual Training School, even were it an efficient institution, as in point of fact it is not, could instruct only 150 boys, or less than three-fifths of one per cent. of our public-school enrollment; as the Maryland Institute, with its meagre facilities and insufficient support, affords only special instruction in art and drawing, it may properly be said that Baltimore, with a population of nearly 400,000, a school enumeration of nearly 100,000, and an annual school expenditure of nearly three-quarters of a million dollars, is practically devoid of facilities for fitting her working classes for their life work. In view of these facts, I apprehend it is not overstepping the bounds of propriety to suggest, in this report, that those children whose circumstances or inclinations clearly point to an industrial career should have facilities for special training bearing on their life work relatively equivalent in extent to the facilities that are now afforded in our City College and high schools to those who expect to follow avocations of a different character. It is not intended by these remarks to claim that public-school instruction should fit persons for industrial pursuits alone, nor that it should attempt unduly to dispose children towards those pursuits, but that it should afford opportunities for qualifying those whose circumstances and dispositions or genius point directly to industrial occupations, for that sphere of labor, just as it now fits others for literary work or the learned professions. That technical education has a claim on our municipal schools equal to that of literary educa-

tion, and that industrial training deserves a place in our schools both as a necessary complement to intellectual training and as a preparation for pursuits involving manual labor, ought to be patent to all.

Without undertaking to discuss at greater length the efficiency or practicability of the instruction in our free schools, attention cannot be too strongly drawn to the fact that the whole tendency of our teaching is the imparting of temporary information to children, less than 4 per cent. of whom pass into the High School, and probably 90 per cent. of whom pass from our primary and grammar schools into various industrial occupations *before reaching fifteen years of age.* On this point I cannot more forcibly and gracefully present the deficiencies of its common-school system than by applying to the city of Baltimore the language used by Mr. William Mather, of England, in his testimony before the Senate Committee on Education and Labor, whose report on labor and capital has but recently been published. This testimony is a valuable *exposé* of the practical relations of our educational system to our industries and, besides being fertile in suggestions of value in reference to the American school system generally, bears directly upon the question now under consideration—the educational needs of Baltimore. Mr. Mather says:

Tendency of our school instruction.

> In my travels through your country in pursuit of my inquiries, I have visited about twenty-two cities, and stayed at each for a while making inquiries. I suppose I have visited over one hundred institutions of various kinds, particularly schools and colleges, and I think I have a pretty fair notion of what you are doing in the direction of education, both generally and specifically. My opinion is, in regard to the question raised by your inquiry, that you would have an immense effect upon the condition of the working classes here if you would alter the methods of teaching in your primary and grammar schools, and very much also in the high schools.
>
> After having given reading, writing, arithmetic, and those rudiments of education which you give thoroughly and intelligently—you seem in that respect to ground the children thoroughly well in the rudiments of education—you then seem to pile upon them a lot of studies which do not enter into their lives after-

Mr. Mather's comments and strictures on our educational system.

ward, when they come to work, and you utterly ignore in all your public schools that element of industrial training which seems to me so necessary for every people—particularly a people like the Americans, so mechanical and industrial in their occupations.

Looking at the course of education of the grammar school, the graduates of that school everywhere appear to me to have spent a great deal of time on the refinements of grammar and of literature—education of very little consequence to them when they pass into their life-employments—and during that time they have no opportunity of acquiring knowledge of the natural laws or elements of chemistry, physics, or the various sciences that underlie all the industries that abound in the country, and into one or the other of which these children are passing. That is all a dark and unknown land to them, and I think it is a misfortune to the working classes of this country that their education runs so much to the side of literature, and not to the industrial and scientific side.

To illustrate how readily children can acquire such information, we have adopted in England, in our new "Board" schools, quite a different system. If you examine a boy of twelve to fourteen years of age in our new "Board" schools throughout any of our large cities, you will find that he will at that age know as much about the elements of simple mathematics, mechanical drawing, physics, chemistry, electricity, magnetism, and all those general elements of science, as many of your boys and girls do in the high schools when they are sixteen or seventeen years of age. That is not owing to the fact that our boys and girls are any smarter or more intelligent than yours, but is owing entirely to the system of education adopted. We are endeavoring to bring this natural system of education in our country to a point where it will be of use to the working classes chiefly; and we endeavor to teach them those subjects that will have a direct bearing on their future employments. Without teaching them a trade, or any particular handicraft, all the tendency of the teaching is to make them either commercially or industrially a success, in the way of having some scientific knowledge which they can utilize as they pass into their various occupations.

I find in this country what I should call lamentable want in this respect. I think it only requires that your public men, your educators, should take this into immediate consideration, in order at once to alter the curriculum of the grammar schools, so that a large portion of the time should be devoted to these more important subjects, and less given to the facts of ancient history or remote matters, which the children will probably never think of when they once pass out of school into the ordinary occupations of life. * * * * * * * * *

Under the ordinary arrangements we are now trying to introduce industrial occupations generally, and we have thus far tried it to the extent of joinery or carpentry classes. We have in several of the Manchester schools put up sheds for carpentry classes, fitted up with benches, and turned every boy in the school, *nolens volens*, who is as much as ten years of age, into the carpentry class for three hours every week, dividing the time into three lessons per week. There all the various timbers from all parts of the world are collected, and a little lecture is given to the boys as to the character of the woods and what they are good for. Then each boy must take his tools and cut from a log a certain piece of timber, under the instruction of the foreman of the department. So each boy goes through the different lines of work in the department, always under instructions. This has had a wonderful effect on pupils, and has really increased their intelligence, so that the three hours lost from the other departments of the school are not, in fact, lost, as the boys keep well abreast with the others in the other studies.

Q. You find this industrial education quite as beneficial to the intellect as the pursuit of the studies in the literary department?

A. Yes; it would almost seem to have revealed to us already that the proper method of training the intellect is to join industrial work to the teachings of the school. We find these boys are more capable of understanding the oral teaching

and they understand better what they read. Their minds are made more reflective and receptive by the fact that they have depended more upon themselves, and put into operation the knowledge that they have before acquired in the schools. That experiment has been tried, as you are probably aware, very extensively in France since the Republic was established there, and with very remarkable results. On seeing, in some cases, the benefits to be derived from that plan, we have made some experiments in England, and we think they are so satisfactory that we shall endeavor to bring to adoption in all our public schools some plan of industrial or mechanical training to go side by side with the intellectual courses.

Q. Will you be kind enough to give us the results of your investigations, if you please? We shall not often have opportunity to get it from so authoritative a source.

A. Well, I hardly think it would be quite pertinent to the question we are discussing. All I need to say is that I think the opportunities in France, Switzerland and Germany for technical training have of late years become quite extensive. In all large cities the training is very thorough. If they err at all there, it is, as I think, that they theorize too much, and cause their students to imagine that, in passing through their technical schools, they have already acquired all the knowledge necessary to make them engineers, chemists, miners, etc., and that actual, practical work in shops, mines and laboratories is not necessary. That is the evil that is encountered by their methods of teaching, and is one that I think neither Americans nor the English are likely to see in their own systems when they adopt anything of the kind.

As you know, your country does possess already a considerable number of very remarkable technical schools, which certainly are not surpassed by any school in Europe. They are schools, however, that are not available for the working classes, as are those of Germany, France and Switzerland, and what little we have done in England. They belong to a higher rank in society, and therefore you have not felt them in your ordinary life. But for the training of skillful managers, foremen, and even proprietors of large industries, about a dozen of the schools and colleges of this country are not surpassed by anything in Europe. I need only to refer to the technological institute at Boston, for example. That form of school is purely technical, and, in the branches which they adopt for their course of teaching, they have a practical method of carrying out all the occupations, industrial and practical, in a simple form before the students which I think is much more to the purpose than anything done in Europe. The American mind is essentially more practical than the German or the French, and in these schools we see the effect of the difference. They keep their eyes fixed upon one thing—that these young men are to become masters or captains of industry—and, therefore, all the teaching has a strong practical bias. The State universities in this country—those coming under the national grant—would, of course, become excellent sources for technical and industrial learning, which might be utilized largely without costing much money, either to the State or to the community.

You seem to have a widespread—almost universal—opportunity for all the people here to get a technical and scientific education. All that you want is a shuffling of the cards to alter the curricula of the various institutions. There is more spent in this country for education than in any other country in the world—both I think by private beneficent individuals who have left money for certain colleges and universities, and, of course, by the generosity of your towns and cities in the public-school system—that is a fact of world-wide notoriety. I do not think the working classes here have anything at all to complain of in regard to education, except that it does not have a strong enough and close enough relation to the industries which the working classes pursue.

When you turn out nine-tenths of all the boys and girls in this country from the schools at the grammar-school age—fourteen or fifteen—you can see how important it is that at that age they have not been carried through that precise

course of study which those may reasonably pass through who intend to pursue education up to the age of eighteen in the high school. I suppose it would be a very simple matter to make such regulations in regard to primary and industrial schools for those children whose parents intend they shall leave at fourteen or fifteen years of age, and not pursue the high-school studies; that in those cases such a change could be made in the curriculum of all the grades that the teaching should be more of an industrial character, and afford the information and training that will enable them to pursue their occupations more intelligently. That, I think, is a thing that the workpeople have a right to claim here—a revision of the course of instruction in the public schools.

One thing I have heard remarked by many Americans, and observed myself as I have gone through the country—that boys and girls just arriving at the age for entering into occupations involving manual labor rather seek what we call in England polite employments—to be clerks, or to be in stores, or some work that does not involve manual labor. Frequently there is considerable difficulty in some of the mills and manufactories in keeping there those who may have commenced to learn a trade or occupation, because they find manual labor uninteresting, as they are sure to find it when they have no knowledge whatever of the meaning of all this labor, or of the scientific truths underlying it all. Their respective powers are not interested; hence manual labor becomes a drudgery, and they soon leave those industries if they have opportunity. Most of your employers say they cannot keep American youths at this work. They do not like manual labor.

We want to elevate and exalt the idea of manual labor in England. We do not want our public-school system to give the children of the working-people the idea that labor is low, uninteresting and vulgar. We want to avoid that by giving them opportunity to take interest in the sciences that underlie all our industries, and so imbue them, through that instruction, with an intelligence that will give them an enjoyment of life unknown to their fathers. That character of instruction it is not possible to get at such schools as I have described.

Opinion of prominent educators.

At a joint meeting of the National Teachers' Association and the American Institute of Instruction, held at Saratoga in 1882, there was a report on Industrial Education by a committee previously appointed, consisting of General Francis A. Walker, President of the Massachusetts Institute of Technology; President M. C. Fernald, of Maine College of Agriculture and Mechanic Arts; President M. H. Buckham, of the University of Vermont; Prof. William H. Brewer, of the Sheffield Scientific School, Yale College; William B. Weeden, of Providence, R. I., and John S. Clark, of Boston. This committee reported as follows:

Your committee chosen to investigate the subject of Industrial Education, and to report thereon to your association, beg to submit the following as their conclusions and their recommendations:

Your committee are of the opinion that there should be incorporated in the present scheme of public education broader provisions than now exist for imparting to our youth the elements of knowledge and skill required in the industrial

arts; not alone for the development of those arts, but also as a part of the general system of public education, having for its object training for citizenship through the normal development of individual power.

To this end they would recommend:

First. The introduction into public schools of proper appliances for the development of the sense-perception of pupils, in regard to color, form, proportion, etc., by contact with models and with natural objects.

Second. The introduction into grammar schools of simple physical and chemical experiments for the purpose of acquainting pupils, through original observation, with the elements of chemical and physical science and their common applications in the arts.

Third. The teaching of drawing, not as an accomplishment, but as a language for the graphic presentation of the facts of form and of matter; for the representation of the appearance of objects; and also as a means of developing taste in industrial design.

Fourth. The introduction into grammar and high schools of instruction in the use of tools; not for their application in any particular trade or trades, but for developing skill of hand in the fundamental manipulations connected with the industrial arts, and also as a means of mental development.

In view of the fact that much misconception exists in regard to giving instruction in the several features recommended, and of the desirability of more information in regard to their practical introduction into schools, your committee suggest a further examination into the general subject of industrial education and its relation to public education.

This testimony, officially published by so representative a body of practical educators as the National Teachers' Association and the American Institute of Instruction, hardly needs supplementing, though much more testimony to the same effect can be furnished, if needed, to serve the purpose in view. In lieu of more extended comment, I herein make a simple reference to Judge MacArthur's late book on "Education in its Relation to Industry," Charles Ham's new book on "Manual Training," and C. B. Stetson's work on "Technical Education," remarking that all of their testimony is in perfect harmony with the strictures contained in the quotations from Mr. Mather's report [Exhibit M] and those made by Dr. Philbrick [Exhibit N] in the report on the City School Systems of the United States, which is in itself a compendium of the subject.

In concluding the discussion of our public-school system I may remark that, broadly speaking, our lower and middle classes get no educational training beyond what is afforded in

Influence of public-school instruction in determining the future career of pupils.

the public schools, and the direction given their studies greatly influences, if it does not entirely shape, their future career and, consequently, in the aggregate, our social, industrial and national life. This statement is simply a reiteration of the fact that if our school instruction, broadly considered, is to fit young people only for literary pursuits and the learned professions, our industries must languish for want of qualified persons to direct them, and lack of skill and intelligence in the performance of the labor necessary to their successful development. On the other hand, if our schools are such as to fit young people for industrial pursuits, as well as for professions and clerkships, thus placing the professions and occupations requiring manual labor on an equal footing in point of dignity and qualified operatives, we may expect a systematic development of our national welfare. By giving more attention to scientific instruction, and to the training of the hand and eye, our public schools would not only do much towards meeting the present requirements of industry, but the reaction upon the schools themselves would be highly beneficial, and intellectual training would assume a high value in all grades of society. Teach the boys in our public schools that to be a carpenter, a machinist, or a moulder, is just as honorable, requires no less skill, and may be more profitable, than to be a clerk, or a doctor, or a lawyer, and there will be hundreds of qualified applicants for apprenticeship in our best shops, and soon educated labor will take the place of uneducated labor, and intelligent mechanics will displace those who refuse to learn more than they already know. But as matters now stand, with scarcely any facilities in our school system for even the most elementary technical training, few boys who leave the higher grades of our schools have any

disposition to enter a workshop as apprentices; not because they have no mechanical genius or capacity for artisanship (for oftentimes their bent of mind is more in the direction of such pursuits than otherwise), but because their education has been such as to prejudice them against pursuits requiring manual labor, and to predispose them towards some other sphere of activity which they look upon as more dignified, and as giving them a higher social standing.

Need of facilities for higher technical training.

It may not be gainsaid that Baltimore is sadly in need of additional facilities for those of her youth who are to become active managers of shops and factories or specialists in industrial occupations. While there are many considerations which should induce the State or our municipality to take immediate action in the direction of providing for the great educational want that has been shown to exist in our midst, one also not unnaturally looks for efficient help in the direction of the great University which has already become so conspicuous a part of our educational system. There certainly are cogent reasons why the Johns Hopkins University should co-operate to this end; prominent among which is the undeniable fact that its trustees are charged with the administration of a bequest that was primarily intended by the testator for the practical education of the youth of Maryland and the South. Upon casual reflection only, an extended reference to the character of instruction in that institution might not be considered especially pertinent to such a report as this, but as one of its principal objects is to secure for our service a sufficient number of young men possessed of such general and varied knowledge and technical training as will fit them for the many positions of responsibility in this service, in which vacancies are constantly occurring, and as many of these posi-

Reasons why the Johns Hopkins University should promote industrial education in Baltimore.

tions call for greater skill and a higher grade of education than are at present contemplated in connection with our Mt. Clare school, the curriculum and methods of the Johns Hopkins University become, as a matter of fact, of great moment in this connection. Such reference is further justified by the close financial and executive relations which the founder of that University sustained to the Baltimore and Ohio Railroad Company, and by the fact that the greater part of its endowment is vested in the securities of that Company, whose successful and economical administration is vital to its own prosperity and existence. If, therefore, some part of the large annual income which the University enjoys through this Company's operations ($136,236), and some portion of the services of its organized corps of experienced teachers and of its extensive equipment can be secured in aid of the higher training in mechanical and industrial pursuits of those to whom we must look for skilled and intelligent operatives, and of the children of our workpeople generally, than our limited facilities can afford, the interests of the Baltimore and Ohio Railroad Company, as well as of all other manufacturing corporations, and of the city generally, will be materially promoted; while the University itself would achieve great renown as the champion of high industrial education for the masses, and its trustees would, at the same time, relieve themselves of the blame which now attaches, in the minds of many of our respectable citizens, to their method of administering the Johns Hopkins bequest. The citizens of Baltimore are not alone in thinking that the managers of the Johns Hopkins University Trust have misjudged, not only the intention of its founder, but also the spirit and the want of the nation and of the present age. In this connection, I again call attention to that exhibit in the appendix of this report (Exhibit M) in which Mr. Mather

Relations of Johns Hopkins to B. & O. R. R.

Mr. Mather's criticisms on Johns Hopkins University methods.

regretfully refers to the devotion of this University to the highest mathematical, physical and medical sciences, and to its decided and especial bias towards original research and scientific discoveries in pure science and other theoretical rather than practical branches, and also to his further remark that "One might expect from so richly endowed an institution a more direct relation to scientific industry than now appears to be the case. With an income of $225,000 a year, it would appear possible for a larger amount of work to be done among the people of the city without in any degree diminishing the high class of instruction in the advanced stages of literary and scientific study." It is unquestionable that its splendid endowment has stimulated literary and scientific education; but, in view of Mr. Hopkins's well-known practical turn of mind and of those terms of his will which are susceptible of different constructions, it is important to consider the character of work to which the University is now devoted, in order to gauge its powers and influence in affording educational facilities to the youth of the States of Maryland, Virginia, and North Carolina, whose preparation for the practical pursuits of life and instruction in branches not taught under our common-school system, for which, in specific terms, it was incorporated and which it is also the testimony of his intimate associates the institution was founded.

The University is not devoted to those purposes for which it was founded.

The present income of the Johns Hopkins University is (closely approximated) $225,000 per annum, derived from an endowment of about $3,500,000; of which $2,207,900 is in Baltimore and Ohio securities. Making liberal allowance for the cost of buildings, apparatus, etc., it is ascertained that an average of considerably more than $100,000 has, yearly, since 1876, been expended for instructing an average each year of only 188 students; that the annual cost of instruction

Amount and disposition of the Johns Hopkins bequests for University purposes.

per student has been at least $700, and that each of the several teachers has had an average of not more than six students to instruct, for which services they have been paid salaries varying from $2000 to $5000 per annum. While these figures are approximate, it is certain that since the institution was opened for students more than $1,000,000 have been expended for the instruction of less than one thousand individuals, for an average of less than two years each. Considering the magnitude of this fund and the almost unparalleled expenditure per individual student, one might certainly look for encouraging results in those lines for which the trust was primarily founded; but, as a matter of fact, out of the 923 students who have matriculated during the ten years of its existence, *fewer than fifty have followed the occupation of merchants, engineers, electricians, manufacturers, or engaged in other industrial pursuits;* while all the rest were educated for professions not directly related to our industries. Even the few who have gone from the University to engage in practical industry have done so by chance or from previous inclination, as the training received there did not particularly fit them for an industrial calling. Certainly those in whose behalf Mr. Hopkins's magnificent bequest was made have a right to expect greater results than these from the proper management of that fund. If the President and Trustees are asked what the University has done for the public, they will doubtless say that it has provided a large staff of able teachers, well equipped laboratories, and carefully selected libraries; that it affords broad and liberal courses of study; that it encourages original research and investigation, and that important discoveries have been made in science; that several serial publications are sent out for general and special information; that gratuitous courses of lectures have been afforded

The course of instruction in Johns Hopkins University does not fit for industrial callings.

What the President and Trustees may claim as the result of the University work.

the public; that the University offers a number of free scholarships and fellowships to the meritorious; and, finally, that an average of nearly two hundred students annually receive instruction in its various departments. The public certainly have a right to ask what some of these important discoveries have been, and to know what practical bearing they have had upon the welfare of the community at large. The beneficial results of these discoveries have not yet been seen or felt in Baltimore. Most of the University's serial publications do not profit the general public of this city, because the matter contained in them consists largely of glittering generalities in science, mathematics and literature, that are of no interest or value to most people, while its public lectures are said to be of such a character as to be understood and appreciated only by those who are themselves specialists, and who might easily go to original sources for the information thus afforded. Likewise it may not be out of place to ask who are the students upon whom the resources of this institution have been expended so lavishly. Are they from Maryland and the Southern States? Are they the sons of poor parents? Are they young men who have to work their way up in the world? Very few of them indeed have been drawn from the laboring classes or from those who are likely to take any part in industrial pursuits. As far as I can ascertain, they are the sons of the wealthy; they are young men who have already received a liberal education in preparatory schools and in colleges, and most of whose parents are amply able to send their sons to any of the already numerous high-class literary universities, such as Yale, Harvard, or Michigan. At any rate it is from this latter class that those who fill the Hopkins scholarships and fellowships are mostly drawn.

Questions concerning the University's methods which the public may properly ask.

The University does not meet the most urgent educational needs of the country and of the present age.

The present tendency of the Johns Hopkins University management savors too much of the classic and metaphysical scholasticism of the Middle Ages. In their efforts to imitate or surpass the great European universities, its President and Trustees seem not only to have ignored the educational needs of Maryland and the South, but of the entire nation. Our country is comparatively new. Very few of our citizens have leisure for the higher study of the classics, for speculative philosophy, or for the study of pure science for its own sake. The time has come when education ought to mean more than it once did. Proficiency in speaking Greek, in composing Latin verse, or in displaying dialectical skill, ought no longer to be the sole or leading purpose of a university training. As education ceases merely to lead a favored few into the realms of classic and philosophical thought, and begins to elevate whole classes of society by increasing general intelligence, and to dignify their labor by uniting the power of the mind with the skill of the hand, it will become a blessing as well as an ornament to society. The continuation of vigorous and healthful national life and development depends largely upon the aid which such education as this alone can afford. A hundred years later we may need to afford more extensive facilities than can now be had in our universities for the highest classical and philosophical culture of men and women, who may then be in a position to devote their whole lives to study and metaphysical discussions; but now we need educational facilities of a different character. Most of our citizens have to labor in some way in order to gain a livelihood. We have vast resources of wealth that are awaiting development. Specialists highly trained in industrial science are needed to direct our manufacturing

and engineering enterprises. As a people we have a bias for the practical. Our citizens have a genius for invention. So great is their ability in this direction that, with scarcely any scientific or mechanical training, they have wellnigh led the world in the number and usefulness of their inventions. If now to this native bias we were to add the power that would result from intelligent training in applied science, and if we could give our artisans a chance to attain the highest skill and intelligence in the execution of their work, for what might we not reasonably hope in the way of national development?

Advantages of a technical department in a great university.

Why should not the Johns Hopkins University sustain a department for higher technical training in industrial pursuits? There are many reasons why such training can be better afforded in a great university than in a special technical school. The same library, apparatus, laboratories and class instruction would answer for both, in many departments of study. The association of the students in the regular University classes with those pursuing technical studies would be mutually beneficial to the students themselves and the country at large. This is shown to be true in the experience of such leading universities as Cornell and Columbia, where classical and technical students are daily brought together. Whatever serves to do away with antagonism, whether between labor and capital, or between industry and culture, ought to be availed of as a social and national blessing. In certain branches, as chemistry, physics and biology, there are no more capable instructors anywhere than in the Johns Hopkins University, and I have no doubt that they would cheerfully render to the city and to this Company the assistance they are so capable of affording, in any commendable effort for promoting industrial education. It is gratifying to be able

The President and Faculty of Johns Hopkins University favor technical training.

to note, in this connection, that President Gilman and his Faculty seem to be in accord with the general idea here advanced. Professors on his staff have expressed and taken great interest in the question of technical training in Baltimore; some have delivered lectures to the working classes; papers on economics and kindred subjects, calculated to bring the University into intimate relations with the people of Baltimore, have been published, while its President has directly expressed his willingness to use the institution as a source of technical training as soon as a practical scheme to that end could be devised. [Exhibit M.] Is it, therefore, too much to hope that, all things considered, the governing body of this institution, recognizing that there is not now an extensive demand, in our locality, for such high-grade literary and philosophical study as is afforded in the Johns Hopkins University, will change their present policy (which appears to look to founding a university that shall favorably compare with the great literary universities of Europe), and will, aided by the city or through their own corporate individuality, forge the missing link in Baltimore's educational system, by establishing, in connection with the present course of instruction, a department of higher technical training, and thus more directly benefit the hundreds of thousands of our citizens, who can never hope to derive any practical benefit from the University as at present conducted?

The Trustees have it in their power to forge the missing link in our educational system.

Besides the great demand in Baltimore for facilities for higher technical training, there are many circumstances that combine to make it a desirable location for a high-grade technical university. It is situated nearer than any other city to Washington, and the teachers and advanced students of such a school could have ready and

Baltimore is a desirable location for a technical university.

comparatively easy access to the Smithsonian Institution and the Patent Office. These places would contribute much towards the success of an industrial course in the University, or of a separate polytechnic school. Washington is not sufficiently of a manufacturing city to sustain such a school. Baltimore is the only city that is close enough to the Capital to profit, educationally, to any great extent by the collection of models, scientific apparatus, and specimens that abound therein. In point of healthfulness, and moral and social influence, Baltimore is probably not surpassed by any other city of its size in the country.

Advantages of having such a school located in our city.

Situated here, midway the Atlantic seaboard, a high-grade technical school would attract students from the North and the South, thus bringing about a better sectional feeling and widely disseminating knowledge of the resources of both the Northern and Southern States. The effect upon our own city would be beneficial in many directions. We would have finer architecture (in which we are sadly deficient at the moment), better sanitary measures, and a greater manifestation of public spirit in all deserving enterprises on the part of our citizens. A polytechnic school, or technical department in the University, would supply a gap in our educational facilities between the education afforded by the common schools and the high scientific and literary education offered by the Johns Hopkins University. It would exert a very healthful influence upon the public schools of the city, by modifying their course of study, by furnishing trained specialists to teach technical subjects, by stimulating young people to avail of their advantages so as to pass into the technical school, and by demonstrating that education is an important factor in fitting young people for skilled labor and industrial pursuits generally, as well as

in fitting them for clerkships or soft-handed professions; and thus those callings involving industrial dexterity and knowledge would, in point of dignity and of qualified and intelligent operatives, soon secure an equal footing with what are popularly known as the "learned professions." A good high-grade technical school in our midst would do much towards supplying competent teachers and suggesting a practical course of study for our evening schools, and for secondary technical schools that would spring up, and the more ambitious of the pupils from such schools would have something to stimulate them to greater exertion; for, besides competent teachers and suitable instruction, there would be the additional incentive of making sufficient advancement to secure admission to the higher technical school. It is well known that many young people in Europe fit themselves for the higher technical institutions by attending evening schools. Finally, with facilities for both higher and secondary technical training to supplement the general education now afforded in our public schools, we might reasonably hope that the frequent labor troubles resulting from the apparent antagonism between capital and labor, or rather the real antagonism between capital and uneducated labor, would cease; for educated labor would soon supplant uneducated labor in all our leading industries. Intelligent mechanics will do more for themselves and their brethren than any number of "labor agitators."

Extracts from an address of Hon. S. Teackle Wallis.

I cannot better close this section of my report than by quoting the following from the address of Hon. S. Teackle Wallis, before the Maryland Institute, June, 1882, to which Mr. Cowen called your special attention:

"Can we let our people go untaught of the arts of construction and design, when all the sister communities with which we rank ourselves are straining every nerve to teach them? Are the mechanic arts so small an element in our prosperity that we can safely let them run or rust in the worn-out grooves of thirty

years ago? When the demand all around us is for skilled workmen, are we to settle down without skill? Are the people who are born to the necessity of labor to be furnished with no means of lightening and refining it? Do the best we may, we can never dispense with the proletary and the drudge; but in heaven's name let us help him, if we can, to something better—let us make the hewers of wood and drawers of water as few as may be. This is not only the duty of a republic and Christian community, but its best interest as well. Think of the weariness that will be lightened by art labor of those who are weak and yet must toil. Think of the penniless and helpless women who will have pleasant and congenial work away from rude contact with piteous temptation. Think of the young men of poor estate whose tastes will be developed, whose natures will be refined, and to whom avenues of independence and perhaps distinction will be opened. Can any man look another in the face and say that these things are not to be coveted? And yet how shall we attain them? The children of toil cannot educate themselves. Of the many even to whom work brings comfort it brings but little more. As maturity comes on the son takes up the father's tools, and his education for the most part ends. What the workshop teaches him, more or less rudely, he learns, and little else. Unless some one helps him to improvement and development, it is only exceptional that he ever reaches them. Individual help may serve in individual cases, it is true, but a large and public need can only be supplied by public effort and the public hand. * * * In this city of ours, and this year of grace, there is not one single public academy of art of any sort except that within whose almost naked walls we are. The elementary instruction in drawing which is given in our public schools is necessarily limited, and a large portion of the pupils are compelled to leave at an early age, as the report of the Commissioners explains, in order to learn trades for their future support. * * *

"It has long been my own conviction that one of the most direful needs of education in this State is the establishment of a technical school for scientific mechanical instruction. There is absolutely nothing of the sort upon the soil of Maryland—a blot indeed upon the intellectual and the business record of a community whose productive and mechanical capacity is so large and varied as our own. The class for whom such instruction is needed are the very ones who cannot afford to seek it at a distance; and except out of Maryland, no Maryland man can find it. Every one who is at all familiar with the subject knows that in the large enterprises where mechanical agencies are needed, the demand is now for mechanics, not only skilled, but thoroughly and scientifically educated. The so-called 'practical man,' whose knowledge is simply empirical, and whose facts lie isolated in a vacuum, is fast being pushed to the wall. He is a victim of the survival of the fittest. Our mechanics are at a sad disadvantage, from the absence of opportunity to qualify themselves for this new order of things. An honorable and lucrative profession, which may well be classed among those best deserving the appellation of 'learned,' is thus practically closed to a large number of the most vigorous intellects of our State."

ADVANTAGES TO RAILWAY INTERESTS OF SCIENTIFIC TRAINING OF WORKMEN.

Effects of technical training upon railway interests.

All that has been set forth in the preceding sections of this report may be considered as paving the way for an intelligent consideration of the bearing of scientific and technical training upon railway interests *per se*. The

wide scope and the importance of the subject bewilder the investigator who seeks to know why technical instruction has not more rapidly advanced and prospered in this country, where the field of industrial enterprise is so wide, and what its effects are upon interests with which railroads are directly identified. An early recognition of the difficulty of securing a proper appreciation of the necessity for more thorough and widespread scientific knowledge among railroad people, led me to afford you a comparison of how it has affected manufacturing and kindred interests in those localities where it has been sufficiently and systematically cultivated, with other places approximately similarly situated with respect to trade facilities and competition, but which have despised or disregarded its aid. This preliminary presentation materially narrows the discussion of technical education from our particular standpoint, and yet I approach this division of the subject with great diffidence, and with full recognition of the pitfalls surrounding one who, lacking experience in many practical details of railway operation and of those industries that have to do with the production of railway plant and appliances, attempts or suggests reformations or modifications of time-honored methods and practices.

Considering its importance and magnitude, there has been a singular dearth of discussion and testimony upon the subject of technical training for railway officers and employes. While there seems to be a general agreement that, because of the enormous capital and allied interests involved, and of the technical knowledge and skill necessary to successfully conduct its varied and far-reaching operations, railroading has acquired the dignity of a profession, fully as exacting and requiring equal professional skill and intellectual attainments as the liberal professions,

Railroading as a profession.

Absence of facilities for thorough and systematic training of railway officials and employes.

I fail to find that any of our railway managers have a proper appreciation of the situation, or that there has been any well-digested effort in the direction of educating railway officials or employes upon systematic lines, such as, for example, produce at West Point and Annapolis corps of young men whose basic education and training, with a little experience, fit them for any position of responsibility and trust in our military and naval service. Unquestionably there must be in many of our large railway organizations those who have long recognized the need of, and would warmly welcome, this educational factor in railway management, and doubtless many of them are, from previous education and long experience, peculiarly qualified for making a forcible presentation of the advantages of—and in view of the great changes that scientific discoveries are making in methods of production and transportation, and the new industries that are continually springing up, I may say the absolute necessity for—a combination of scientific and technical education for the operatives of the transportation service of the country. But, unfortunately, men of this type are, as a rule with few exceptions, overtasked with responsibilities and harassed with anxieties that leave few opportunities and little inclination for expressing their views on any subject foreign to their specific duties.

Dearth of testimony as to effects of technical instruction upon railroad interests.

Having accepted the task of investigating this subject, I shall endeavor to crystallize for you the testimony of such well-known authorities as, though not actually railroad men, have themselves been connected with the details of industries more or less related to railway interests, and who are, therefore, competent witnesses; and I shall further endeavor to set forth as clearly and succinctly as possible, such conclusions and considerations as have been evolved from a careful

and somewhat prolonged inquiry and study of this subject from various standpoints. I do this in the hope that my labors will be fruitful of results in the direction of at least stimulating those in our service who have its welfare at heart (and especially those officers who are charged with making net results) to inaugurate a new policy, which shall require of all candidates for all positions, however insignificant, that are in the line of promotion, a reasonably high standard of qualifications, and shall then look to fostering and developing the youth of the service into a corps of educated operatives, mentally and mechanically skilled in their various handicrafts, with at least sufficient breadth of knowledge and capacity to render unnecessary and unjustifiable the selection of men outside the service to fill the highest positions of responsibility and trust, even in the administrative and executive staffs of the company. Such a policy would not be chimerical, but one easy of accomplishment with (considering the interests involved) an insignificant expenditure, if accorded the hearty good-will and co-operation of those upon whom devolves the duty of developing our resources and increasing the net earning capacity of our system.

All appointments of railroad officers in line of promotion should be based upon high standard of qualifications.

If the testimony previously set forth affirmatively shows that scientific and technical education stimulates, develops and secures economical processes in the manufactures and other industrial avocations, a much stronger case can be made out in favor of broad technical education in connection with our railways; which, collectively, employ in the production and repair of plant, more workmen than are engaged in any other class of commercial business.

In the same ratio that our extensive railway system surpasses all other branches of industry in the magnitude of its business, the number of its departments and the

Scientific knowledge secures economy in all railroad departments.

interests affected, is there greater need for economy of administration and greater necessity for the application of the highest obtainable scientific knowledge and manual skill to its various operations. It has become the almost universal practice of our great railway corporations, and especially those whose lines are reaching out into undeveloped and sparsely settled territory, to assume the entire repairs of their plant, even when they amount to practical reconstruction, and there is also a steady tendency on the part of such companies in the direction of manufacturing their own equipment from raw materials. This places them in the category of manufacturers, and makes them amenable to the laws and factors regulating production, and, further, makes applicable to them much of the testimony heretofore given as to the value of technological instruction in mechanical pursuits. Because of the nature of their service, involving the transportation and care of many lives and valuable property, no less than as a matter of economy, is it of prime importance to such corporations that, in the construction and in the repair of their rolling stock and appliances, they should employ workmen of exceptional competency. It is unnecessary, in this connection, to comment upon their great responsibilities as guardians of life and property, but from a merely sordid point of view a few illustrations will demonstrate that, in their extensive mechanical operations, economy and credit result from the employment of intelligent laborers, who understand the theory and purposes of their work, and who have the scientific knowledge that gives them, beforehand, a realization of the proper quality and quantity of material to be used, and enables them to anticipate the results of the labor they must expend upon that material to produce given results; *per*

Railway corporations have become manufacturers.

contra, that corresponding danger and loss result from the employment of workmen who, lacking this knowledge, are compelled to experiment upon their material, and who require constant supervision, instruction and re-instruction.

Methods of transportation revolutionized by Watt's inventions and introduction of steam.

The fact is that with the discoveries or, more properly speaking, inventions of Watt and the introduction of steam as a motive power, began a new and eventful era in the history of mechanical science. The wonderful development of land and water transportation that followed the inauguration of steam locomotion created a demand for a class of operatives, artisans and mechanics before unknown. Entering upon a new field of operations wholly unrelated to their previous experience, without preparation or present instruction, save what they absorbed in the performance of exacting duties on the railway, in the workshop and in the engine and boiler-rooms, men who had been "picked up" from many walks of life, and who altogether lacked scientific training, would naturally be guided solely by "rule-of-thumb" practice, and their lives were sure to be narrowed, until they acquired a pride in being known as "*practical*" men—a term nearly synonymous with the habitual but unreasoning work of many familiar species of the brute creation. The railroad workman of to-day is largely the outgrowth of this condition of affairs, and yet is not wholly responsible for his educational deficiencies. When learning their trades railroad apprentices were generally placed under "*railroad men*" of the "*practical*" type I have described; who despised or affected to despise scientific knowledge and scientific methods of operation; generally not because they understood or were able to weigh their bearings and value upon their pursuits, but because, knowing absolutely nothing about them, they thought thus to disguise

Evolution of "practical" men.

Defective methods of training apprentices.

their ignorance. Under such circumstances apprentices received little if any special instruction, but were mostly left to pick up their trades as best they could. Of course, under such a system, instead of having their special aptitudes developed they, in turn, became "*practical*" men; and of this type is the present rank and file of railroad operatives. It is therefore not remarkable that blunders and accidents frequently occur: that the lives and property of the public should be entrusted to men whose limited knowledge frequently does not enable them to judge of or to reflect upon the responsibilities attached to their several duties, painfully illustrates the recklessness and indifference to public duty that characterize our age and country.*

Perhaps no large class of men are more subjected to public observation and criticism than the employes of transportation companies, and there is certainly no other

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* That this is neither an unjust nor groundless statement can be easily proven from the abundant evidence before me, and also from personal experience. In too many shops apprentices are looked upon as convenient lackeys, and although they may have strong predilections for certain kinds of work they are more likely to receive rebuff than encouragement in attempting to utilize their abilities. It is very probable that much industrial usefulness both to employers and society has been blighted in the bud from lack of recognition and wise direction.

A very interesting article, opportunely appearing in the November number of the *Century Magazine* (Vol. 33, No. 1) as this report is passing through the press, very fully discusses "THE NEED OF TRADE SCHOOLS," and especially this particular point of apprentice education, and in that connection I commend it to your notice.

Mr. Robert Thomas Eadon, an English manufacturer, says: "I am fully impressed with the importance of technical education. Some time ago I was in Bradford, and I saw that preparations had been made worthy of the town. There is no trade, however wanting it may be in taste or form, that does not benefit in the hands of a tasty man. One great reason why technical schools should be encouraged is because of the very great division of labor that takes place in some of the largest engineering establishments. There is a great tendency to put a boy at one machine, and he understands but little beyond that machine. The result is, though he has been in an engineering shop, he has no idea of the work carried on as a whole, when he comes out. He is a helpless man if you take him away from that one machine. It may not be always to the interest of excellent workmen to inculcate their skill in the minds of the boys under them; in fact, they may not have time to do it; but the advantages of a college or school of this kind will be that if a youth has a desire to improve himself, the facilities will be offered, and at such a rate as would be attainable."

Railway companies dependent for success upon the courtesy and intelligence of their employes.

class that can more materially promote their employers' interests by the exhibition of such courtesy, manly spirit of accommodation, and general information upon current topics as a fairly liberal education manifests, and yet you cannot have failed to notice—and as a railroad manager to regret—what is so commonly commented upon by the observing: the intellectual deficiencies and narrow-mindedness of this very class. That our railway operatives are one-ideaed is small matter for wonder; it would be more remarkable if, as a class, they were otherwise. I have already pointed out that the operating departments of a railroad which most expose their employes to public observation are those which require the longest and most exacting apprenticeship for the acquisition of that degree of knowledge and expertness which secures the performance of their functions as public carriers with safety and dispatch; that the heads of administrative and operative railway departments, who must of necessity be men of technical knowledge and familiarity with all the intricate workings of their respective branches, which can only be acquired by progressive service, generally commence their careers in the lowest grades, with little or no preparatory education; and yet their duties throw them into constant contact with a public which is indifferent to the measure of their experience, but which judges them by the standard of business men, and demands of them gentlemanly courtesy and general and varied knowledge, and which, I may add, favors or obstructs the operations of a railway company according *as its officials* are judged worthy of commendation or condemnation. The managers and owners of railway property are the ultimate sufferers from the deficiencies and derelictions of subordinates in this regard, and yet *they* are mainly responsible; for if,

instead of exacting a high standard of qualifications on the part of applicants, they open their service to uneducated boors and then fail to provide them with facilities for acquiring, with manipulative and technical skill, at least the rudiments of those branches of knowledge and the opportunity for extended observation without which no man can be intelligent, liberal, progressive, how can it be expected that those employes, when taxed with the cares and anxieties of an active business, shall display such enlightenment and refinement as will reflect credit upon themselves and service?

Lack of general and technical knowledge among railway operatives.

Many of our railroads employ *armies* of people, all of whom are supposed to be technically expert in their various avocations;—and they need to be. Even a good track laborer is not found ready made. It is a well-known fact that in many railroads only one or two men in a road gang know how to properly tamp a tie so that it will not require resetting the same season; and I know of extensive lines that do not possess a foreman—perhaps not a supervisor—who can adjust a curve with instruments. Does it not behoove executive and administrative officers who are entrusted with such vast interests as those of railroads to look well to the qualifications of their operatives? A recent and generally accurate writer has fixed the value of railroad property in this country at one thousand millions of dollars. Another writer says that the number of skilled laborers required in the operation of railroads is much greater than is commonly supposed, embracing large numbers of men not usually classed as railroad operatives. In such extended enterprises the efficiency of the unit—the individual workman—becomes an item of grave economic consideration; for if it be true that the value of the individual's work (whatever it be) is increased through

The economic value of special training for railway operatives.

greater intelligence and special training, though it be only by a few cents per day, the total is of no inconsiderable moment, when his services continue through a series of years and when, instead of one workman, thousands are employed. If even a slight deficiency in the skill and intelligence of one workman makes a few cents' or a few dollars' difference in the cost of the products of each week's labor; if the incompetency of one foreman or one manager lacking scientific training does usually—as so positively stated by competent authorities—net an appreciable loss; multiply the result to corporations like, for instance, our Eastern trunk lines (one of which employs at least 50,000 people on that part of its system east of the Ohio River, and more than half as many more west of it: others may exceed or nearly equal this enormous force); realize that in such extensive organizations few if any of the practical details of the operating departments can be accurately gauged by those whose interests are most vitally concerned; comprehend how many important matters, involving grave consequences in their execution, must be entrusted to superintendents, master mechanics and foremen; then obtain a correct measure of their education and general knowledge (to say nothing of their scientific attainments), and you will begin to appreciate the importance and bearing of this question of technological education, and the enormous losses the lack of it yearly entails upon investors in railway securities.*

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*It is a great misfortune to our railroad properties that their owners are not brought into contact with the staff and rank and file of their operative departments, so as to appreciate their value and deficiencies or their needs and aspirations. Says Mr. Kirkham, in his work on the Maintenance of Railways, p. 35:

"No one who is dependent upon the goodwill and fidelity of others for the maintenance of his interests can afford to shun their acquaintance or permit them to remain in ignorance of his good intentions towards them. On the contrary, his duty and interest alike demand that he should cultivate such relations with them as may be necessary to assure them of his constant and

Fidelity but one of the elements constituting a valuable railroad officer.

That most of those who have risen to positions of responsibility and trust in railway service in this country are honest and faithful, goes without saying; but integrity and industry are not sufficient: they should also, as aforesaid, be men of intelligence, and should possess not only a special knowledge of their own departments, but also an accurate understanding of related departments of the service. By intelligent direction of those under him a foreman may largely increase the efficiency of a score of workmen; and, on the other hand, by failure to comprehend the scientific principles involved in the work he superintends, he may cause constant loss or make destructive accidents possible. And what is true of a foreman applies with greater force to his superior officers. Where is the intelligent railroad official who has failed to realize the many problems yet to be solved in the matter of railway operations and appliances, and who is not also conscious that, for the most

The value of the services of foremen and other railway officers dependent upon their training.

friendly regard and the beneficence of his purpose. When it is necessary that men should entrust the immediate and general management of their property to others they must do so unqualifiedly and heartily, but such delegation of power should never extend so far as to relinquish the right and duty of enquiry into the status of subordinate employes. The proprietor will ever consult his welfare by such manifestation of interest in his servants, and any general or prolonged neglect on his part to fulfill this cardinal duty of ownership will redound to his great and permanent injury. By many owners such manifestation of interest is thought to be subversive of discipline, and it is possible that they have been encouraged in this monstrous delusion. It is a sufficient answer to say that where the owner of a railroad cannot come in contact with his employes without jeopardizing the discipline of the organization, it ought not to require an outbreak among his servants, or the destruction of his property, to convince him that there was a radical defect somewhere in its method of administration. The discipline of an organization that is dependent upon terrorism, upon ostracising or sequestrating the employe, upon separating him from the acquaintance or sympathy of the owner, is manifestly a gross perversion of responsible methods of government, and wherever practised evinces mismanagement, and may be accepted as evidence of discontent and insubordination and outrageous disregard of the rights of owners by those who encourage or practice it. If the tendency of corporate history in the United States teaches one fact more clearly than another it is that the owners of such property will find it to their advantage to manifest immediate and personal concern in its affairs and in the affairs of those who operate it, lest their personality be lost and their property alienated or its value seriously impaired. The possession of property presupposes the duty of guardianship, including a paternal interest in those who operate it, and its preservation to the owner will ultimately depend upon the general and wise exercise of this duty."

part, railroad officers and operatives are much more likely to fail in appreciation of, and even to oppose, improvements and contrivances of merit in this field worked out by others, than to originate them?

The exigencies of railway service require men of special training, of peculiar qualifications, of minute practical knowledge. There are no important exceptions to this rule in any of the departments or branches of the business. To perform their duties wisely and efficiently supervisory officials must be relatively as well skilled as the general manager. They must possess a general knowledge of the branches of the service to which they are assigned, as well as a particular acquaintance with the peculiarities that are special to the immediate positions they hold. This general and particular knowledge involves an intimate acquaintance with the property, its defects, its resources and its peculiarities, and presupposes prolonged association and years of observation and thought, without which such knowledge is not attainable.

Technical experience must be supplemented by general knowledge.

In a recent work on "Railway Expenditures; Their Extent, Object and Economy" [p. 111], Mr. Marshall J. Kirkham says:

Testimony of Mr. Kirkham as to the unrecorded loss incident to the employment of new and inexperienced officers.

"Those not familiar with the practical operations of railroads can hardly estimate the innumerable mishaps and unrecorded losses that occur to a property in consequence of the introduction into its life of new and inexperienced officers,* of officers unacquainted with the duties they are to perform, unacquainted with the manner in which these duties have been performed in the past, or the scope and circumstances that are expected to characterize them in the future. The result is always disastrous, no matter how great the ability or how upright the intention of the new official. Under the most favorable circumstances he is placed in the position of a man called upon to act without possessing the definite and trustworthy knowledge necessary to enable him to act intelligently. He has everything to learn, from the arrangement of his files and office furniture to the unrecorded policy that has governed his predecessor. He has to learn the local and foreign geography of the line, its peculiarities, traditions and prospects; what it possesses and what it does not possess; its contracts, agreements and leases; the officers and employes who operate it, and the people who give it

* And they never will be able to appreciate these mishaps and unrecorded losses, for the reason that it is the interest of the class who precipitate them to conceal the real facts from the owners of the property.

support. All these things must be learned by rote before a new officer is either valuable or trustworthy. In the acquisition of his knowledge he is harassed by doubts, and his path is otherwise beset by obstacles."

I have already referred to the increasing tendency of railroad corporations to repair and even to manufacture their own plant. This seems to have been the traditional—as it is certainly the present—policy of the Baltimore & Ohio Company. It is patent that if everything, or most of the important things, needed in the operations of the service could be manufactured from the raw materials, in our own shops, by our own employes, of as good quality and character of construction as can be had elsewhere, and always with economy, the interests of our stockholders would dictate that policy. But, in order to produce in the shops of corporations of such extended and diversified interests as railroads, work of a high order, with economy, very material progress must be made over the situation as I now regard it. We have seen that no productive enterprise can in our day be made an economic and commercial success without intelligence and skill, and that, other things being equal, it will be profitable just in proportion to the degree in which those elements are utilized. Surely, enough has already been said to establish these two elements as of the highest importance in the production and in the operation of railway plant and appliances. I presume no more difficulty is experienced in procuring for railway service men who have manual skill, and who are frequently superior artisans in their several occupations, than it is to obtain them for other pursuits; and I know that many railway shops contain many such men, whose worth as mechanics cannot be denied, and who have doubtless made the best of their opportunities. But the great want in railway service is men who combine technical skill with disciplined minds and broad intelligence; men who, with

The B. & O. policy of producing railway appliances from crude material.

Need of reform in methods of shop-work and management.

The demand is for skill combined with general and technical knowledge.

professional experience and knowledge, possess minds disciplined to accurate observation and logical thought—qualities that come from sustained mental application, and are not likely to exist without it; men whose qualifications make them worthy of promotion, and guarantee efficient and economical management. I cannot too often emphasize the statement that, to the extent such qualities are lacking in heads of departments, and *intelligent* service is lacking in the rank and file, railway operations will be conducted crudely, inefficiently and with high percentages of operating expenses to gross revenue. While this is so patent as to be undeniable, it is certainly a fact that we have not generally been successful in securing enough of educated skill and intelligence to even leaven the mass of "*practical*" men who constitute the operating forces—to say nothing of other departments—of our railways. Whether this be because the managers of railway interests are apprehensive of the disapproval of their stockholders if they pay more than the *lowest* market price for labor, or personally entertain too indifferent notions respecting educated talent to induce them to compete for it with private firms and local corporations that *do* value it at its commercial worth, is not for me to say; but I do assert that it is folly for such long-lived corporations as railroads to hazard their future prosperity for temporary profits, as they do when allowing and encouraging their administrative officers to seek and to prefer uneducated—because nominally cheap—labor. If we expect to operate such properties on business principles, and not for mere speculative results, our railway managers must provide for the better education of the rank and file of their employes.*

Scarcity of educated talent in R. R. service.

* The purchase of low-grade materials because they are cheap and can be made to serve present purposes is even a lesser evil than depending on low-grade labor. Parenthetically, a writer already quoted says:

Historically considered, the first servant of a railroad in whom technical knowledge is an essential qualification is the locating, followed by the constructing, engineer. Our colleges and technological schools are yearly turning out, in increasing numbers, young mining, civil and mechanical engineers—the latter in less numbers than the wants of the country require. Electrical engineers and industrial chemists are also making their appearance, and as electricity, mechanically applied, is coming to the front as an important accessory of railway service, and will soon form an essential part of our transportation operations, this class of specialists ready made to our hands will, when competent, easily find lucrative employment, and it will be many years before they overstock the telegraph and railroad markets alone. The industrial chemist is also destined to play no insignificant part in the railway management of the future. But none (or at least very few) of the members of any of these, or, in fact, of any other classes, enter upon professional life understanding, or qualified to meet, the necessities of railway service. It might, indeed, with some reason be assumed that a competent *civil engineer*, at least, would be qualified to undertake *railway* engineering, but a rail-

Types of railway servants.

Schools not connected with workshops cannot furnish the kind of training that is needed in railway service.

"Only an experienced and farseeing manager, I have remarked, can withstand the seductive influence that envelops an article of prime necessity to his company when offered at a low rate. The fact that its ultimate cost will be out of all proportion to the temporary saving is lost sight of or ignored by some. The immediate and visible reduction in the cost of operating, and the notoriety that will attach to him for effecting such reduction, are too strong for a weak man to withstand. This would not be the case to the extent it is if so great a proportion of the loss which a company must ultimately suffer in consequence of the purchase of inferior material was not unavoidably blotted out or covered up under foreign headings, and remained, in consequence, unknown. . . . In considering the cost of car and locomotive wheels, axles, frames, springs, bolts, nuts, and kindred appliances, we find the relative cost between the good and the bad article is not alone manifest in the price paid for the article itself. It will be discovered that the use of the inferior article materially swells the disbursement accounts for deaths and injuries from accidents, for losses and damages, and all the multitudinous expenditures enumerated above in connection with the use of inferior lubricants, including the cost of repairing tracks torn up by derailed trains, the interruption of business and its manifold losses, the swelling of the account for wages, and finally the cost of repairing the injured equipment."

way engineer is not, to the present time, the creation of any educational institution in this country. Upon this single point, a paper just read before the Society of Arts of the Massachusetts Institute of Technology (one of the best conducted in the country) is exceedingly interesting, and I therefore append it hereto as Exhibit T; recommending it to your careful perusal. Much of what is therein said may be taken to apply with equal force to other branches of railway service, and it will well repay the reading.

Competent men of varied attainments a necessity in railway service.

In railway service, especially, there is frequent necessity for sending to a distance, and beyond supervision, one or more thoroughly competent men, who shall not be simply mechanics, in the ordinary acceptation of the term, but who shall be able to turn their attention to work coming under their notice, whether they have before done that thing or not. I think we are all prepared to admit that at present such men are rarely found enrolled in the rank and file of railway mechanical departments; yet it is testified by many manufacturers who have afforded their employes the advantages of technological instruction, that they have no difficulty in filling such positions with boys of 20 or 21 years of age, whom they send long distances and place in their hands work with which they have had little or no previous acquaintance, and by their intelligence they not only give the greatest satisfaction, but frequently develop into competent teachers of others.

Young men of intelligence may be entrusted with responsible duties.

Quite enough has been said in this report to show the necessity of technical knowledge on the part of machinists and other artisans employed in constructing and repairing railway equipment. As a class, the men thus employed are doubtless of average skill in their several trades, but it is apparent that in such a hard service as railroading,

where machinery, rolling-stock and roadbed are, as a rule, taxed to their maximum strength and capacity, even a slight lack of appreciation, on the part of mechanics and those supervising them, of the special and technical requirements of their work will result in the failure of their productions at critical moments, always to the pecuniary loss of the owner and sometimes causing serious disasters. Mechanical trades are at present acquired in this country through very general instruction or in shops devoted to special construction. When work is stagnant in one branch of a trade it is generally active in other directions, and the mechanic must, from necessity, often drift from that kind of work in which he is educated to others to which he can apply only manual skill, with a smattering of general knowledge, perhaps altogether inadequate to the proper performance of his new duty. Even our foremen, master mechanics and supervisors, who are, almost without exception, men of practical knowledge and long experience in their particular lines of work, have very seldom received such general or technical instruction as would enable them to appreciate the effect, upon their own productions, of changes in methods of operation such as are constantly occurring in all transportation service and to meet them.

Need of flexibility in workmen.

Every one understands why locomotive engineers should be well educated, and yet we know quite well that very few have enough education to enable them to respond to emergencies requiring higher qualities than mere mechanical skill, courage and local knowledge.* In our road

Education of engineers.

* Says Mr. Wm. Fairbairn, of Manchester, F. R. S., and an authority on the subject:

"The locomotive-engine drivers and stokers have only been known to us for the last twenty years, but they constitute at the present moment an important branch of the industrial community, and so far as their acquisition of knowledge and respectability of character are concerned, we are all, individuals as well as the

departments very few foremen or supervisors understand—or if they understand can intelligently describe—the causes which deteriorate their track or bridge structures, or otherwise affect their every-day work.*

I might in similar manner go over the whole list of railroad operatives, but it is unnecessary. The reason for all their educational deficiencies is apparent when we consider how few opportunities they have for acquiring theory and practice in the same place or at the same time during

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public, deeply interested. Engine drivers and stokers, above all others, should have a regular and rigid course of training. They should have a keen eye and a clear perception; they should be taught care and attention to signals, and every minutia connected with the rules and government of the lines on which they are employed, and, above all, they should be instructed in the management of the engine, the value of time, and the absolute necessity of working the distance according to the time table and those established rules by which they and the public are to be governed in their departure from and arrival at the different stations. A driver should also be acquainted with the principles upon which the steam in the boiler is generated, its elastic force, the security and free working of the safety valves, and, in fact, in order to prepare him for public service, he should attain his degree and character in the Workingman's College before he is considered eligible to mount the foot-plate or to handle an engine. Lastly, other classes, such as blacksmiths, carpenters, masons, bricklayers, turners, tilers, moulders, etc., exclusive of innumerable others, such as spinners, weavers, dyers, printers, etc., employed in the manufacture, might each of them reasonably demand to be included in a national system of industrial education."

* In this connection the following is suggestive:

"The acquisition of knowledge, as every one has occasion to remark, is not of so much value for the specific thing that we learn as for its contingent revelations, the correlative ideas that it suggests; and so it may be possible that even an imperfect conception of the fixed expenses of a railroad may afford suggestion to those who are not disposed to regard the information itself of especial value. Thus, while we may not care what relation the fixed expenses bear to contingent outlay *as a whole*, if we knew accurately the effect of wear and tear of traffic upon particular classes of expenses, and the percentage of deterioration from natural causes, there can be no doubt that the knowledge would prove of value to particular men, if not to railway men as a whole. The truth of this bears apt illustration in the case of track-rails.

"Practical men with whom I have communicated as to the relative deterioration of rails from climate and traffic, have stated that a rail will remain fit for use forever if trains do not run over it; others put the deterioration from natural causes at two per cent.; others at five per cent., and so on. As a matter of fact, the deterioration of rails due to climate, while not great, is marked and cumulative. The deterioration from climate in the case of other materials is, as a rule, much greater. It is not necessary, nor would it be proper, here to enter into a minute or scientific statement of the effect of climate upon different classes of material. The subject belongs more properly to scientists. I merely cite the case of rails to illustrate the lack of information on such subjects by those whose duties are connected wholly with the care of such property."—[Marshall M. Kirkham, "Maintenance of Railways."]

railway machinery, appliances and methods, has led a number of managers to seek the services of the graduates of technical schools as assistant foremen, assistant supervisors, assistants to engineers of roadway, master mechanics, etc. After some actual experience these young men are put in line of promotion, and inquiry shows that generally they stand well in their respective corps, but even after going through the shops, such graduates continue more theoretical than practical, and this constitutes the great objection to railroads taking into service technological school graduates, instead of *educating* their own young men.

As already shown, combined mental and physical education alone give satisfactory results, and no substitute for this method will yield a railroad the highest value of its talent.* The Pennsylvania Railroad pursues the plan of exacting of the graduates of technological institutions entering its service a novitiate in the construction and repair shops at Altoona before they are permitted to enter active service. Many young graduates of technical schools so highly value the opportunity of studying the scientific methods and enjoying the instruction of the Altoona shops as —it is said—to disregard pecuniary compensation, in a wise desire to avail of the fine training obtainable there. At the same time, if I am correctly informed, this instruction is neither so specific nor so thorough as it should be, nor can any method by which it is sought to qualify young

Policy of Penna. R. R. in employing college graduates.

* Dr. Quincke, formerly Professor of Physics in the Berlin Polytechnic School, and now Professor of Physics at the University of Heidelberg, pointed out to the Royal Commissioners the error made by many in believing that any polytechnic course of instruction could *by itself* teach a student (for instance) to erect an engine, work a blast furnace, or manufacture sulphuric acid; the real object of a technical school being to facilitate the transition from pure science to practice by means of appropriate lectures and laboratory work, which are obviously insufficient to prepare the student for carrying on actual work where practical experience is needed.

men as railroad officers be successful which does not provide for theoretical instruction in those branches of knowledge that comprise what may be designated as railroad science, *pari passu* with actual commercial shop-work; the latter illustrating and confirming the former. This method of combining theory and practice so as to give both an educational value has during the past year been pursued with signal success in preparing the apprentices at Mt. Clare for cadetships in the B. & O. service, under the program announced in your circular of January 15, 1885. When it became publicly known that technological instruction had been inaugurated at Mt. Clare, we were besieged by applicants for admission to the school whose social status, scholarship and culture were infinitely superior to anything found among the 147 apprentices already in service, whom we had examined under the terms of that circular. Many of these young gentlemen entered as regular apprentices, without favorable discrimination as to hours of work or pay; in fact, they accepted low wages for services far more valuable to the company than those of the average uneducated apprentice. By supplementing their shop-work with the class-instruction which was specially adapted to it, they have achieved excellent records, and now possess a very solid foundation for a higher technical course, in which theoretical instruction may predominate, and after a year or two of further study they will honor the service in whatsoever positions may be assigned them.

The method now in force at Mt. Clare for securing educated apprentices.

With educated and intelligent workmen and operatives, railway companies will have fewer accidents, and the saving on this single account would doubtless often more than cover the cost of a liberal educational provision. Of the graduates of a technical school at Lille, M.

Intelligent workmanship will reduce accidents.

Hovarez says: "Those engaged in working mines soon perceived that workmen who came from this school heated their boilers better and with less coal than did the other workmen, and that they escaped many accidents and repairs and stoppage of machinery." If this be true of simple stationary engines, how much greater must be the effect upon such complicated machinery as railroads operate! On this point Judge McArthur says that technical and scientific education becomes a subject of universal interest; that—

> "The ordinary accidents to which we are exposed arise in too many instances from some error in the work of the draughtsman or the machinist. The unexpected fall of buildings, and their bad construction, as developed in cases of fire, are sometimes attended with horrors that curdle the blood and sweep away precious lives by the most excruciating deaths. The wheel or axle of the locomotive may be unsound in material or model, and the train in its rapid flight be plunged over a viaduct or embankment, bruising and maiming its living freight and sending our best and most beloved ones into the grave without warning or preparation. Boilers explode, machines are shattered, owing to defective work of some kind, and the newspapers publish a daily catalogue of disasters more appalling than the carnage of war. The lesser evils are also considerable."

Uneducated workmen unable to utilize scientific discoveries and methods.

Many of the discoveries of the day are not used because workmen do not understand them or are incompetent or unwilling to utilize them, and there is also an acknowledged deficiency in the ability of railroad employes to determine, with scientific accuracy, the shapes and dimensions which are best adapted to stand the strains of the various working parts of the locomotives and other machinery used by railroad companies. Though much has been done in this direction by specialists, it is more than probable, from their testimony and from the deficiencies of such machinery, that scarcely a tithe of the facts that may and ought to be known in this matter are yet discovered, or, where known, availed of. Such investigations, owing to the scarcity of men combining both practical and theoretical knowledge, are so costly and uncertain, and require so much skill and technical training to conduct them, that manufacturing

Industrial problems may be economically solved in conjunction with school work.

companies cannot often afford to hire specialists or bear the expense of experimenting; but in a school connected with railway shops, under competent guidance and instructors of ability, much may be done, as a part of the school and shop-work instruction, that will, at the same time, accomplish desirable results in other fields. It is the testimony of many of our best educated engineers that the engineering profession in all its departments is continually hampered by the want of more extensive and more accurate experiments. They say that "in far too many matters they have nothing to rely on but the imperfect or imperfectly reported results of antiquated experiments." The difficulty is that most of their experiments and observations have necessarily to be of short duration, and that they have insufficient data upon which to base their conclusions. If, now, we can introduce the scientific method of original research and experiment into our workshops; if, instead of one experimenter, there may be dozens of wideawake, observing and energetic men in search of scientific and mechanical truth; if, instead of one experiment at a time, there may be several under different circumstances going on at the same time; if, instead of continuing a single day or a single week, these experiments in the workshop may be continued through months and even years; if, in other words, our workmen, or a large number of them, can be taught to regard the workshops themselves as great laboratories for continued research, experiment and observation with a view to gaining original information for practical purposes; then there need be no more complaint in the realm of applied science about inadequate data and uncertain conclusions.

But there are other important considerations which should induce railway managers to promote the education

of their people. The advance of our civilization is seen in an awakened eagerness for scientific discoveries, and disposition to use scientific investigations, not alone as a method of mental gymnastics, but as a torch to illumine great fields of productive and commercial industries and to shed light upon the pathway of the laboring masses. What the outcome of this spirit of invention and discovery in the realm of applied science will be can only be conjectured, but whatever other industries may be affected by it, none are more likely to reap rich harvests from its encouragement and growth than those railroads that, in point of qualified managers, scientific specialists and intelligent and skilled workmen, are best prepared for promptly utilizing such developments. No industry has fixed boundaries, nor can any be said to have reached maturity. The inventions of to-morrow may necessitate radical changes in the processes and in the kind and manner of manipulating the machinery of to-day. We have seen how combined scientific and technical education conduces to economy and net results, by cultivating habits of thought and observation, and developing special aptitudes; thus enabling workmen to utilize improvements and inventions at large, and encouraging them in attempting inventions and seeking for more economical methods of work, which inure mainly to the benefit of the employer. Original mechanical contrivances; new—and improvements in existing—processes and methods of manufacture, are seldom the result of accident or the fruit of a low degree of intelligence. Analysis of the history of industrial and mechanical progress demonstrates that the large majority of inventors who belonged to the artisan class were deserving, faithful, investigating and generally well-educated men, whose

Scientific investigation of industrial problems profitable to railways.

How improvements in mechanical processes are achieved.

minds, through technical training, had acquired flexibility, and whose faculties were stimulated by study. If *our* workmen do not make inventions and develop economical methods of labor, others in the employ of rival companies will do so, and the active competition of the age will give those corporations that are advanced enough to cultivate the intelligence of their employes material advantages over others. Even if, in order to neutralize this superiority, we are willing to pay well for the privilege of utilizing improvements and inventions owned by antagonistic interests, we may still lack the power, through want of intelligence and skill on the part of our own people. Because of the lack of scientific knowledge that would have enabled its managers to appreciate the value of a meritorious improvement, a railroad company with whose affairs you are familiar, now has to pay a rival corporation for the use of a slide-valve for its locomotives, invented a few years ago by one of that company's employes, who, for a nominal consideration, would have licensed it to manufacture this very valve for its own use and for sale to other companies.

Unwisdom of discountenancing inventions by employes.

In this connection I again quote from Professor Huxley's declaration that "the advance of industry in all countries depends on employers being able to find to their hand persons of sufficient knowledge and sufficient flexibility of mind to be able to turn from the one thing they have been doing to something different, according to the nature of the improvement that has been made"; and that "the development of industry under its present conditions is almost entirely the result of the application of science to the development of mechanical processes of complexity, requiring a great deal of attention and intelligence to carry them out."

Prof. Huxley's testimony as to dependence of industry upon educated knowledge.

In this connection, the citation of two curious circum-

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stances, bearing on a branch of trade in which we are greatly concerned, will interest you. The iron and steel workers of Cheshire and Lancashire are the most skilled manipulators of the common metals in the United Kingdom, and their mechanical instinct has been hereditary for centuries. The first Earl of Chester was Master-of-Arms to William the Conqueror. His workmen resided in the villages of those counties, and when the use of armor was discontinued they were still notable workers in iron and steel. Their descendants still call their tools and implements by Norman-French names. *They possessed hereditary skill and knack such as no other workingmen in the Kingdom had; yet from all this body of skilled labor no inventions came;* they were and are satisfied to go on as their fathers and forefathers had done, and the inventions which have made this the age of steel came from those who were destitute of their practical skill. The introduction of the hot blast in the furnace; the application of the cold blast in the Bessemer converter, which changed liquid iron into steel; the production of steel direct from ore on the open hearth, and the discovery of the basic lining, by which phosphorus is eliminated and all grades of iron made convertible into steel, revolutionized the mechanic arts; and yet it is remarkable that only one of the inventors of these processes was directly connected with the iron trade, and not one came from all this body of workmen whose skill in manipulating iron had descended to them through many generations. The hot blast was discovered accidentally by an engineer; Sir Henry Bessemer was an engraver; William Siemens was a mechanical engineer and electrician, unconnected with iron industries; Gilchrist Thomas was a member of the Civil Service; James Watt was an instrument maker; so that the iron and steel industry owes its development to

Who are the valuable inventors in metallurgy.

science, distinct and apart from itself, and in no material degree to its rule-of-thumb workers.

The rapid and important improvement of machinery and mechanical appliances has placed many of our older railway companies at a disadvantage, in respect to economical construction and repair, in that their shops are filled with machinery and appliances of obsolete patterns, costly and slow in action, while works more recently established are generally equipped with the latest and best the market affords. Mechanical processes enter so largely into railway operations, and the results of using crude help or plant so directly and seriously affect the percentage of operating expense to gross receipts, that one unacquainted with the history of railway management would naturally, but vainly, look to railway shops for the latest improvements in processes and machinery there used; for probably few managers would have the temerity to propose the periodical replacement of obsolete for the latest approved practice and inventions in shop-work, though able to prove the wisdom and economy of such a procedure.

Disadvantage of using antiquated machinery, and crude workmanship in railway shops.

I might almost indefinitely multiply testimony respecting the difference in efficiency and economy between educated and uneducated labor; but I apprehend it is only necessary to prompt the minds of those experienced in handling labor to the line of reflections above suggested, to lead them to convictions respecting the economy in time, material, supervision, and value of products turned out by educated help fully as strong and emphatic as those I have quoted. At least those employers and supervisors of labor who possess the kind of knowledge that can only be acquired from the combined reading of books and extended observation know that at the present time most workmen in America have little *general* intelligence and less *general* skill; that most of

Most workmen ignorant of natural laws and scientific methods.

them see machinery in motion governed by laws of the existence and nature of which they are totally ignorant; that they see operations performed the nature and scope of which they are incapable of understanding; that they are accustomed to make parts of machinery which, together with other parts of machines made by other workmen, go to make up an organic whole, and yet neither know nor care to know how to put those parts together, nor how to operate them when combined. It is needless to comment upon the results of such ignorance, except to point out that, aggregated, it must entail enormous losses.*

How best to remedy this condition of affairs is a problem of very serious import; but I have written this report in vain if it has not at least demonstrated that, if we are to continue manufacturing our own plant, it will be cheaper to manufacture also our own skilled artisans, mechanics and other operatives out of the crude materials which abound in the shape of applicants for apprenticeship, than bid for them in the market; especially as, thereby, we will secure a corps familiar with the needs of, and attached by various ties to, the service.

Cheaper to educate apprentices than to purchase skill and intelligence in the market.

Let me here add a little to the testimony in the first section of this report as to what technological schools are capable of accomplishing, especially in aid of railway interests. I call your attention to the mass of evidence contained in the Exhibits to this report, and in further and

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*While labor with hand-tools and machines should be wisely blended, yet, since machinery has a constantly increasing share in the conversion of material into useful forms, the educated mechanic should know how to design, construct and assemble the parts of a machine, as well as how to make its product; and excellence in construction is to be sought as a most valuable factor in instruction.

The power of the engineer to decide upon general grounds the best form and material for a machine, and to calculate its parts, is vastly increased by blending with it the skill of the craftsman in manipulating the material, and the fact that the product is to be tested and used kindles interest in its manufacture and furnishes additional incentive to thoroughness and exactness. [Catalogue of Worcester Free Institute.]

effective support thereof I adduce the testimony of Mr. J. Scott Russell, the eminent English engineer and builder, and other intelligent directors of labor. Although a highly educated man and an able scientist, whose scholarship has received recognition from several of England's learned societies, Mr. Russell is not a mere theorist on questions relating to manufacturing and constructive industries. When a boy he served a regular apprenticeship at a mechanical trade, after which he long followed the business of practical engineering; gaining such prominence that the building of the famous GREAT EASTERN was entrusted to his superintendency. The testimony of a man who thus combines great intelligence and learning with experience in the workshop, in the art of originating, and in the supervision of workmen, ought to command careful consideration from those who are largely interested in enterprises requiring constructive and mechanical ability.

What technological schools accomplish.

In his "Systematic Technical Education for the English People," a book published in 1869, Mr. Russell says:

Testimony of J. Scott Russell.

"It seems to me almost an axiom that intelligent men must do better work than boors; that trained, skilled men must do better work than clumsy and awkward ones; and that the more any man knows of the objects and methods of his own work, and the work of all those who around him are engaged in co-operation, the more likely he is to do his own part well, so as to exactly fit into and form one with his neighbor's work. Thus I think that an intelligent community of workmen will get through their work quicker, will fit its parts more nicely, will finish off everything more sharply, will waste less material by trial and error, and so give higher value as well as quality and durability to all their work, than ignorant, unrefined, uneducated men.

"Unhappily, mechanics, when taught to workingmen, is generally either taught superficially, unphilosophically, or with little or no reference to the business of their life. Economy of bodily strength, best ways of handling things, best ways of helping each other, best ways of carrying, lifting, shifting things—these are seldom taught. Some algebraical formula, or abstract geometrical diagram, is put before the poor mechanics and called science; as well call it magic!"

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"I will now come to practical matters which show directly the results of technical education in the production of one of its chief objects—the creation of wealth. It is notorious that those foreign railways which have been made by the people themselves, in the educated countries of Germany and Switzerland, have been built far cheaper than those constructed by us in England; *it is known that they have been made by the pupils of the industrial schools and tech-*

Bearing of technical training on railway construction.

nical colleges of these countries; and I know many of their distinguished men who take pride in saying that *they owe their positions entirely to their technical schools.* I find everywhere through their work *marks of that method, order, symmetry, and absence of waste* which arise from *plans well thought out, the judicious application of principles, conscientious parsimony, and a high feeling of professional responsibility.* In the accurate cutting of their slopes and embankments, in the careful design and thoughtful execution of their beautiful but economical stone masonry, in the self-denying economy of their large span bridges, the experienced traveler can read as he travels the work of a superiorly educated class of men; and when we come down to details, to the construction of permanent way, arrangement of signals, points and sidings, and the endless details of stations, we everywhere feel that we are in the hands of men who have spared no pains, and who have applied high professional skill to minute details. It is well known that many years before we could follow their example, the engineers of the German railways had introduced a system of constructing and uniting to each other the iron rails of the permanent way which made them cheaper, safer and more durable than those employed in England. * * * It is remarked by every traveler that the work of their railway stations is, when compared with ours, much more beautiful, convenient and fit, both within and without; the construction of their trains, the proportions of their carriages, the fitness, convenience, and comfort of their internal arrangements, all tell to the disadvantage of ours, and the only thing in which our railways excel theirs is in high speed. Theirs, on the other hand, are economical in capital and high in revenue."

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Economic value to employers and to society of educated workmen.

"To return to the mere vulgar usefulness of educated human beings. I will venture a remark from personal experience in my profession, which I trust may illustrate the vast importance to us of educating not only governors, or masters, but of extending a high scientific education and skilled technical training to the workingmen of all skilled occupations. It is this: The community at large are deprived of the use of enormous treasures in mechanical invention, and enormous progress in scientific arts, by the fact of the general want of education in those who practise them. It may not be known, but it is yet true, that the mechanical power employed in all our manufactures is infinitely more costly than it need be. It is equally true that some skilled men of such professions know thoroughly how to produce immense economy in the production and use of mechanical power, but that we dare not put the means into the hands of the uneducated masters under whose control they would be applied. I am not now speaking of a loss of five, ten, twenty, or thirty per cent.: I say that I know that *we are only utilizing one-tenth to one-twentieth of the power we employ and waste, and that an economy of one hundred, two hundred, three hundred, and four hundred per cent. is quite within our power so soon as a better informed, higher skilled, more perfectly trained class of men and masters shall arise,* who are fit to be trusted with the use of instruments and tools at present utterly beyond their comprehension, control or application to use. Special knowledge is not sufficient to produce even the best special results. The best workman is always the one who has a knowledge of tools and principles beyond the direct requirement of his work, whatever that may be. The best scientist is always the one who acquaints himself with other departments of science than the one to which he is specially devoted. The best artist is always the one who does not limit himself to his specialty, but studies the whole circle of art. This breadth of study and work gives a breadth of knowledge and training which decidedly strengthens a man for his specialty, be that however rude."

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"I am continually asked why a man whose business it is to turn a furrow, dig a ditch, wheel a barrow, move bricks, saw trees, plane boards, quarry stones, get coals, or hammer hot iron, need know anything more than how to handle a spade,

use his arms, or manipulate his hammer ; and whether more knowledge than that would not spoil their minds and set them above their work.

"To this I can answer that, taking the matter on the very lowest grounds, I never saw any kind of labor in which the man of greater intelligence could not do more work in shorter time, to better purpose, and with less waste, than the mere uneducated savage of civilized society. I have seen at the plough the clod-hopper, little more intelligent than the well-fed brutes in front of him, let his clumsy plough wriggle on with small care how it went, and little thought as to how its work were done ; and I have seen the skilled ploughman, with half the number of horses, and with no greater toil to them, cover double space on the same kind of land with clean, straight, even, well-finished work. The one knew all about the draft on his team, the strains on his harness, the adjustment and action of his plough, and felt at his fingers (instinct with intelligence) every variation of direction or force which indicated whether his own slight pressure on the plough-stilt should give it bias one way or the other. The one man avoids difficulty because he sees it beforehand ; the other endures it because he is in the middle of it before he knows it, and so must go through it. The intelligent ditcher who lays out wisely his day's work before he puts a spade in the soil, has so forecast and arranged it that every bit of earth is moved out of its old place into its new the shortest way, over the least distance, with the least force. The skilled navvy can do double the work in the day of the equally stout but unskilled rustic ; and if this be the case in the lowest operations of moving earth, it needs no iteration on my part to show that in every succeeding stage of work—in getting stone or getting coal—even before we come to shaping, selecting, fitting, fixing and finishing articles of workmanship, the more intelligent and better trained man will use his mind to apply his strength and wield his tools so as to spare his strength and material either for himself or his master. Estimated, therefore, on the lowest scale of social value, education means economy, profit, absence of waste."

The educated man makes the cheapest and best workman for the most vulgar pursuits.

Mr. John W. Nystrom, at one time Acting Chief Engineer, U. S. Navy, who received his education in the Royal Technological Institute at Stockholm, in which theoretical training is supplemented by workshop and laboratory practice, in a report advocating a *Techno-Naval Academy*, says :

Testimony of John Nystrom on technical education.

"There is now a very distinct line drawn between scientific and practical men. The more we study and cultivate the branches separately, the more distinct will this line become and the less will they understand each other, and may ultimately fall into irreconcilable estrangement. The prejudice against science is in our day a very serious evil.

"A blind man can walk on roads and streets, but when he finds an obstacle must stop ; at a ditch he may tumble into it ; he cannot turn from his accustomed track. Such is the case with many practical and otherwise most valuable men working without a knowledge of physical laws. In order to follow up the improvements of the age, the track pursued by our fathers must often be abandoned and a new one selected and surveyed for ourselves.

"Without the application of science we go ahead without knowing where we are going. In verification of which we have many examples in engineering blunders, sometimes submitted to a committee of inquiry, which may result in the discharge of the engineer, accompanied by extravagant abuse of the department concerned, and the evil only temporarily remedied by substituting another, who will most likely not repeat the same blunders, but will do some-

thing worse. There is yet no attempt made to permanently remove these evils and secure success in our enterprises by proper institutions."

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"At the present time scientific attainments and true practical knowledge are very little respected; physical laws established by the Creator of the universe are often derided as theoretical; ignorance has taken the lead, and rules in the ascendant, and often adopts that which is opposite alike to science, experience and common sense."

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"We must in all ages and in all countries expect active and operative minds to come forward with ingenious contrivances, sometimes with wild ideas, ridiculous in design, and wrong in mechanical principles; but then it is the function of science and knowledge to step in and correct their aberrations, or, if necessary, to guard against or prevent their further introduction until developed to an educated design, which otherwise might lead to destruction of life and property.

"On the other hand, most ingenious and valuable ideas are sometimes submitted to the opinion of scientific men with no practical knowledge, who may condemn them from an imperfect perception of their merit. It is only a knowledge of combined theory and practice that can accomplish justice in all cases."

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"We have numerous examples in Europe, particularly in Russia, where engineers are educated to only scientific attainments, and who, when they enter a machine shop or engine room, are incompetent for the proper conception of work, but are, nevertheless, entrusted with responsible stations, where their practical achievements only lead to mischief.

"Our experience throughout life teaches us that a practical man without science seldom makes such serious blunders as a scientific man without practice. The merit then of the *Techno-Naval Academy* would be in the education of engineers in the practice, and not with mere scientific precepts of professors.

"The writer has often observed the career of students from colleges, and regrets to say that too few of them turn their attention to work. Those who have received scientific education generally prefer to become professors, scientific advocates, patent agents, lawyers, philosophical secretaries, etc., etc., while the practical operations of our workshops suffer in the extreme. Every once in a while we have a steam-boiler explosion, killing off a great number of men, with great destruction of property; we build vessels which will not float; are often disappointed in the performance of vessels and machinery; we waste great amounts of fuel, and we make extensive and costly experiments in steam engineering without consulting the physical laws involved in the operation.

"In iron foundries castings are often made with too little metal, and sometimes too much; the hydrostatic action of the fluid cast iron in the mould is rarely understood; the laws of shrinkage, strain, direction of crystallization, and sinking in castings of irregular form, are not generally comprehended; and many defects of experience exist which often cause the loss of valuable castings, for want of applied science. When the casting turns out a failure, it is generally said that the foundry superintendent is not skillful, or has not experience enough, which often means that he has not made blunders enough to secure success.

"The general impression about the business of moulding and casting, as well as all other branches of mechanic arts, is, as has been repeatedly told to the writer, namely, that 'the profession cannot be brought within the scope of science, and must be learned by experience alone.'

"On the other hand, scientific men without technical education, entrusted with practical problems, are generally not familiar with important circumstances involved in the operation, which accordingly results in blunders; they are then derided as 'scientific men.'"

England has long had a large body of skilled workmen,

by whose labor she has attained commercial and manufacturing pre-eminence. But mere "rule-of-thumb" work, without general intelligence and scientific knowledge, was insufficient to hold that pre-eminence, which has several times been in jeopardy, and is now maintained only through recognition of the fact that her laborers must be intelligent, and that their technical and scientific education is a national work. In this connection I call your attention to the following and to other quotations in Exhibit M about the waste of material, etc., in construction, due to lack of educated labor.

England unable to maintain her industrial pre-eminence by manual skill of her workpeople.

In the report relative to technical education by the Schools Inquiry Commission of 2d July, 1867, Mr. McConnell, one of the English jurors, is quoted as saying:

"In the class for which I was juror for England, I made a very careful examination and comparison of our locomotives, engines, carriages, railway machinery, apparatus and material with those exhibited by France, Germany and Belgium (which governments support schools of technology). I am firmly convinced that our former superiority, either in material or workmanship, no longer exists. . . . Unless we adopt a system of technical education for our workmen in this country, we shall soon not even hold our own in cheapness."

The Royal Commissioners make frequent mention of the fact that in the most enterprising and successful factories and shops of Europe they found men peculiarly fitted and trained for their special duties placed at the head of the various departments and shops as managers and foremen. But they particularly noticed that very many of these firms had been compelled to make provision for the training of their own managers and foremen, so as to secure men specially adapted to their particular industries.*

Trained specialists in industrial establishments of Europe.

* It will be noted that the British Commissioners' report expresses astonishment at the great progress on the Continent of industrial methods and the successful application of scientific principles to manufacture since the Paris International Exhibition in 1878. [Second Report, Vol. I, p. 505, *et seq.*] They say that the great industrial establishments are almost perfect in their management and efficiency of production, especially in France, in Germany, in Belgium and in Switzerland, the countries where technical education has been most effectually tried and adopted. In 1878 the English nation was conceded to be far ahead of

In his testimony before our Senate Committee on Education and Labor (Exhibit R), Mr. Mather said that, as the result of the long and thorough study of our institutions which he had made preparatory to reporting to the Royal Commissioners on the industrial and educational facilities of the United States, he had recognized the "native ingenuity" of Americans in contriving helpful devices in various industries, and particularly in matters of transportation; but he had also seen that, notwithstanding their enterprise and ingenuity, Americans owed much of their rapid advance to technically educated Europeans, and that in so far as their achievements are the result of native efforts, it is due to lately established technical schools. I quote his language on this point:

Mr. Mather's testimony before U. S. Senate Committee on Labor on industrial education.

"The workmen of America have been educated and brought up under conditions different from those prevailing in Europe. It is impossible to traverse this vast continent (America) without witnessing the evidence of originality of application and of a growing development due to education in the scientific arts. In the railroad system, from the locomotive to the baggage car, there are original design and naked ingenuity in every contrivance; in bridge-building, great daring and ready devices for temporary, yet safe, structures; in the navigation of rivers there are boats which differ from all European systems. The shallow rivers like the Mississippi, in summer, are navigated for thousands of miles by steamers drawing less than twelve inches of water. The Ohio conveys thousands of tons of material from Pittsburgh by boats drawing nine inches of water. Towns like Chicago, Denver and San Francisco were built under difficulties which require an entire departure from all old methods of applying science. The produce of the great agricultural regions suggested new methods of tilling, sowing and reaping, and in agricultural machinery the Americans showed how quickly and directly science could deal with vast products, which would rot in the field but

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these countries in the production and manipulation of machinery, but the Commissioners now admit that much machinery of all kinds is produced abroad equal in finish and efficiency to that of England, and that it is applied to manufactures with great skill and intelligence.

When we remember that England has heretofore taken the lead in European manufactures; that she has decided advantage over her Continental rivals in the abundance of crude materials and cheapness of fuel; that heretofore her machinery has been acknowledged to be far superior to that used in the factories of other European countries; that the concessions above referred to are made and published to the world by a commission consisting of English manufacturers, legislators and educators; and when we consider further that not until very recently has England done anything worthy of mention for the education of her artisan class, while Continental nations have made strenuous efforts to this end through the establishment and munificent endowment of polytechnic and other industrial schools, the economic value and great importance of technical education appear in a most striking light.

for mechanical skill to preserve them. The same aptitude that dealt with the overwhelming abundance of the West has turned to account the sterility of the East, where in Maine, New Hampshire and Vermont the mechanical skill of the farmer in devising economy has contributed as much to his support as his knowledge of cattle and crops.

"It is, of course, in the more recent structures and modern mechanical appliances that the evidence of scientific truths and methods is observable. The rough-and-ready contrivances of early railroad development indicate originality and 'mother wit,' but in the waste of material and crudeness of design may be noticed the absence of technical or scientific training on the part of those who conducted extensive engineering and mechanical operations in those days. The gradual diffusion of science is very marked in the rapid reconstruction, during recent years, of the great railroads of the past, and in the new main lines. Also in railway plant generally, the old is being replaced by the new, and the latter exhibits high theoretical knowledge combined with practical ingenuity.

"The Americans undoubtedly owe to many European engineers the rapid advance they have been able to make in their public works. The conservation of water power for the use of the mills at Lowell and Lawrence, in Massachusetts, is due to the eminent hydraulic engineer, Mr. Frances, an Englishman who practised for forty years in America, and who is deservedly esteemed as the highest authority on hydraulic engineering in America. Although a lucrative field was, in the early days, open to European engineers and machinists having a thorough scientific knowledge of their profession, yet it is evident that they soon found apt scholars in America, who, as they acquired some theoretical science, launched out into new paths, untrammeled by the traditions of older countries.

"Even the science of foreigners, when applied here, takes different methods. The Englishmen and Germans become bold and self-confident to a degree only manifested by rare men in Europe. The everlasting thirst for *something new* excites, stimulates and drives men to venture into untrodden paths of applying their knowledge."

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"All these evidences of scientific skill (in America) speak well for the methods of education in the recent past, so far as it goes, but other influences, such as 'necessity the mother of invention,' and the presence in America of foreign experts, will account for much of the rapid growth in the mechanical arts. The future development will depend upon a population not compelled to dare and endure and experimentalize for 'very life.' In the past the waste of material has been excessive. To make the best use of a given quantity of material requires a sound knowledge of its properties and of its disposal in the arts and manufactures by scientific methods. In this direction the technical and science schools already instituted have accomplished much in providing foremen and managers, chemists, miners and intelligent employes in the engineering and manufacturing products. (For schools referred to see Exhibit L.)

"It is remarkable, however, that in the great centres of the mining and iron-producing districts, where so large an amount of mechanical construction is carried on, as, for instance, in Pittsburgh, Chicago, Detroit, Cleveland and Philadelphia, so little has been done by the owners of large establishments, or by the town or State authorities, in the direction of technical schools, or evening science schools. These industries represent a large proportion of the working population in those large cities, and yet the owners of works have to rely upon the scientific knowledge obtained through many institutions remote from these districts."

Mr. Mather is only one of many who have seen and regretted—and have called attention to—the lavish waste of material and reckless expenditure of time and money,

and even sacrifice of human life, that have resulted from our lack of scientific knowledge and failure to appreciate the economy of its application to productive industries. The facts cited in his report form an eloquent appeal for its greater application to our arts and manufactures.

Elementary knowledge is most easily, economically and thoroughly acquired in youth, when the mind is free from cares and distractions inseparable from manhood. Upon this point Mr. John B. Jervis, a civil engineer, who has lately written on the construction and management of railroads, well says:

Elementary knowledge economically acquired only in youth.

"Though there are exceptions, it is a general truth that it is expensive to learn a new occupation in maturer manhood; and consequently, the railway company that commit their business to unskilled or uneducated men, must be at the expense of educating them during their supervision of business, and while they are learning its arts and duties; meanwhile depending on advice, trusting to the guidance of others as they may chance to find out matters beyond their powers of criticism. Can there be a doubt that the proceedings of the pupil will often be undecided, wavering, and wanting in that system indispensable to the efficient and successful conduct of intricate and important business? Now, it has happened that such men have in some cases eventually acquired a good knowledge of business, but it is obvious that this education has been of the most expensive kind, and, what is particularly important, it has been at the expense of the proprietors, who paid a salary while the incumbent was obtaining the qualifications that would enable him to earn it.

"It will be admitted that training of some sort is necessary for every department of labor or business.

"A man who is educated to a particular business—whose time is devoted to a full understanding of its requirements—and who is stimulated by the consideration of professional reputation, is more likely to conduct affairs advantageously than one who picks up his ideas at random, and though doing some things very well, will often fail in respect to others. Certainly the important matter of maintaining the track and machinery of a railway should be committed to the most competent hands."

Capacity of technological school graduates for work.

I also repeat that it is the universal testimony of employers that the graduates of good technological schools have a greater capacity for work than other workmen of average intelligence, and that they easily adapt themselves to changes of employment, oftentimes to the great financial advantage of their masters.

It has already been shown that many manufacturing companies in Europe have recognized the importance of

affording technical training to their employes, and I have also called your attention to many workshop schools in various parts of Europe that are wholly or partly supported by proprietors. So valuable is such previous technical training recognized to be, that I have learned of a large number of instances where employers are in the habit of sending to home and foreign exhibitions, at their own expense, those of their young people most advanced in technological study and of quickest perceptions, in order that they may study new inventions, machinery, etc.; while many others allow their apprentices and young men to leave their work an hour or more before stopping-time, on class-nights, without abatement of their wages. Many European manufacturers and the managers of some foreign railway works now call the particular attention of their workmen to new designs, improvements in machinery and methods of work, and to successful inventions that have been made by other workmen trained in technical schools. Such workmen, partly as a result of greater intelligence, recognize and are stimulated by the great possibilities that are constantly opening up to them, and partly through a love of study and investigation acquired in technological schools are constantly on the alert for opportunities to accomplish something above the performance of mere routine duty; whereas, lacking scientific knowledge and technical training, they would probably not only have contentedly followed in the footsteps of their predecessors, willing subjects to the tyranny of routine, but would, in all probability, have opposed the introduction of improvements made or suggested by others.

Recognition by European employers of the value of special technical training.

Intelligence and the love of investigation profitable to employers.

Valuable information in the same strain is furnished by a number of the leading manufacturers of England, who

Further English testimony of the value of work-shop schools.

state that, as one beneficial result of the instruction given their employes in classes and evening schools, they have perceptibly advanced in intelligence and, understanding better the directions given them, and the objects had in view in the work assigned them, their usefulness and value have been materially increased. That whereas, before they received a technical training, their workmen would have to return to the shops to get personal instructions on every emergency or case of difficulty, the same workmen, after acquiring the ability to make sketches and to reason about their work, now make suggestions themselves and remedy such difficulties without delay; also, that instead of requiring a draughtsman or foreman to look after every separate shop, the young fellows who are growing up under their system of technical instruction are making their own drawings, working from them, fitting their work together and erecting it with great economy, because one man now does what it used to require a separate man in each department to accomplish; and, generally, that their workmen are, at a much earlier date than formerly, acquiring intelligence and ability to understand and to execute their tasks, and at much less cost to the manufacturer. [Royal Commission, Second Report, Vol. II, p. 430; Vol. III, pp. 217–18.]

Educational and mechanical value of drawing.

One of the most valuable and effective agencies for increasing the intelligence and efficiency of workmen is instruction in drawing. The habit of working from drawings and from careful measurements; the ability to make drawings and to construct machinery and other products according to scale (which may readily be acquired in a school of technology by any one of ordinary intelligence) will always be a source of profit and economy to employers, and is probably of greater importance in railroad shops

than in any other branch of industry. Very few of our artisans (and in this general term are included carpenters, shipbuilders, masons, machinists, etc.) know enough of the principles of projection to be able to read the working drawings placed in their hands, to say nothing of the skill required to make such drawings, and are therefore obliged to work under constant supervision and at reduced wages. While in some few cities drawing is taught in the common schools, it is an exceptional case where enough of the theory and application of projection is taught to meet this universal want of artisans; while, as a matter of fact, no school-child of either sex can well afford to dispense with the peculiar discipline which is derived from instrumental drawing and free-hand practice. A finished draughtsman must, for many years to come, be the production of special schools. Professor Thompson, of the Worcester School of Technology, says that—

> A boy who spends two hours a week in drawing and the rest of the time in working at the bench, learns his business faster and becomes more skillful in it than one who works all the time, and he calculates that the productive efficiency of every machine-shop would be increased thirty-three per cent. if every journeyman could read any common drawing and work by it.

Professor Ware, of the Boston Institute of Technology, says:

> "Drawing is an invaluable element in a general education. To the workman it is of the greatest practical use. It makes him more intelligent and serviceable. If he attains to real skill in the use of his pencil, and develops the tastes and talents that cannot without this training be either discovered or made use of, he becomes a valuable person at once. Every branch of our manufactures is suffering from the want of just this intelligence and skill."

That technological schools adapted to the wants and standard of our workmen will do much to prevent and overcome labor troubles, is self-evident. Such troubles frequently occur through the inability of the workman to understand the mutual relations existing between labor and capital. Dense ignorance makes men the easy and

Labor troubles largely attributable to ignorance.

ready tools of demagogues, while the influence of a few well-educated, thinking mechanics, scattered among a mass of workmen, is an invaluable nervine in labor agitations.

That such training as is here advocated will also be a source of profit to railway corporations, by diminishing the tendency to dissipation on the part of workmen, and thus increasing their efficiency in the shops and on the line, is easily demonstrable. It is not putting it too strong to say that ignorance is the great centre from which radiate intemperance, coarseness, brutality, vice, conceit, arrogance, irregular habits, and almost every other trait of character that a good workman should *not* possess. An ignorant and unskilled workman can never be anything more than "a hand," often untrustworthy and troublesome to his employers and to the community in which he lives, while an educated laborer is a valuable citizen in any community, and likely to be the helpful adviser of those availing of his services. In both Europe and America many promising enterprises are rendered unprofitable by the bad characteristics of employes, and capitalists abroad are beginning to see that the surest remedy for this evil is the education of the laboring classes. In Chemnitz, Saxony, one of the greatest centres of European industry, where the standard of education among all classes, including the poorest, is exceptionally high, there is a corresponding high standard of decency and self-respect among the laborers. Very little time is wasted through intemperance, and the workmen attend their tasks with great regularity. (Royal Commission, Vol. I, p. 304.) The same kind of testimony comes from Windisch, Switzerland, and from many other places, where the employers look after the education of their laborers. It is claimed that in Windisch dissipation is not known to the managers of shops. (Vol. I, p. 273.)

Ignorance the prolific source of many vices.

Mr. William Anderson, a member of the Institute of Civil Engineers, and also of the Institute of Mechanical Engineers, says:

"When we established works in 1864, we used to have great difficulty as regards the drinking habits of the people, and we had great difficulty in managing them generally. Monday was a blank day, for instance; but that is completely changed now, since the establishment of schools. The young men now engaged in the works, who have passed through the schools, are of a very different character from those we used to have. Instead of having letters from our men that we can hardly decipher, we get well-written letters, sensible in every way; and this improvement in elementary education has improved the whole moral tone of the class from which our workmen are derived. We are getting a better raw material to deal with, and the young men are beginning to show a desire for self-culture and self-improvement."

Ignorance encourages dissipation in workmen.

It is not surprising that men whose intelligence is so little developed that they have no source of pleasure or enjoyment within themselves, should easily acquire habits of dissipation. The workman who is incapable of deriving enjoyment from useful reading and elevating thought; whose home is probably nothing more than a place to eat and sleep in, possessing none of the comforts and social attractions that emanate from culture, and whose associates are not of a type calculated to elevate or inspire him with aspirations to do something and be somebody, is handicapped in the march of morality and civilization, and naturally falls an easy victim to habits of vice and dissipation. It is the universal testimony of managers of labor that the usefulness of workmen diminishes in proportion to the frequency with which they spend their evenings in places of dissipation. This is natural, for after a night or even an evening spent in such haunts, a workman must resume his work dissatisfied with himself and with his surroundings; his brain will be dull, his hand unsteady. He will be irritable and unwilling to receive instruction or advice; indifferent as to how he does his work, or, if he can escape the penalty, if he does it at all. Of course I do not mean to intimate that all ignorant laborers are dissipated

Dissipation disqualifies for good work.

or predisposed by ignorance to vice, but it is an established fact that the mass of people who are vicious and dissipated are, if not wholly without mental training, mentally and physically unskillful, and that an educated man is not nearly so apt to indulge in dissipation as an uneducated one. A man whose mind has been cultivated as his hands become skillful, finds enjoyment in his work; pleasure and profit in reading useful books and papers, and in innocent social pleasures of a higher type than can be found in bar-rooms or on the street-corners. His home, however humble it may be, is likely to be tidy, and to afford him an appreciable degree of comfort and enjoyment. Such a man is free from many temptations, and the probabilities are strongly in favor of his leading a sober and useful life; which, of itself, is a guarantee of fidelity to his employer. Instead of diminishing his ability for efficient work he will, in all probability, when out of the shop, bestir himself in acquiring useful information and in taking that rest which nature demands, and which will enable him to resume his duties with efficiency and satisfaction to himself and to his employers. It follows, therefore, from this point of view alone, that the necessary result of educating laborers will be increased profit to the capitalist and the elevation and greater remuneration of the laboring classes.

Culture guarantees fidelity and enhances a workman's usefulness.

Trade schools, by providing useful and congenial employment for the leisure time of apprentices, have an especially beneficial effect upon their future; keeping them from idleness and dissipation; increasing their self-respect and moral tone and confirming them in studious and steady habits at a critical period of their lives. One of the greatest advantages that comes from operating evening schools, or classes that require evening preparation of

The advantages of trade schools in educating and preserving the morality of apprentices.

lessons, in connection with shops employing many apprentices, is that such schools fix the knowledge and continue the habits of thought and mental application acquired in school-life, at a time when all previous school-acquired learning would otherwise become so indistinct as to exert little if any influence in forming or confirming in them tastes for useful work and enjoyment.

Says Mr. J. Scott Russell:

"I am hopeless in the matter of educating the 'workingman' who has grown up into manhood without education. For the most part, such men are too old to learn. I have never seen, but exceptionally, much good come of trying to drive figures and geometrical problems, and mechanical theorems, and light and shade, into the head of a full-grown workman who had failed to get a good education when young. There have been brilliant exceptions—how brilliant! how few!"

I also quote again from Mr. Nystrom:

"It is not expected, neither is it necessary, that the student shall become an accomplished mechanic, but the object is to concentrate his mind on the work about which he is studying and calculating. When confined only to books and blackboards, his conceptions rarely extend any further. He acquires the knowledge by routine, as it were; the study becomes tedious to him; and when brought to bear on practice, the most simple problem may confound him. When a student is brought up in the combined science and practice, however, he generally acquires a taste for work—good workmanship and proper proportions—and the application of his science becomes a pleasure. He studies mathematics at the same time he learns drawing; physics and mechanics at the same time he makes his tools and models for machinery. His science is applied as fast as it is acquired, and he will never forget it. When a student is thus equipped for the journey of life, he is able to bring such physical laws into action as to secure success in all his enterprises. He will be able to record and report back to the institute his future experience, by which the most thorough connection may be kept up between science and practice.

"As things now stand, a man of most valuable information is not able thus to record his achievements; in fact, he may not know himself the very laws of his success; his experience and valuable knowledge die with him; his toiling successor will reiterate his blunders, and gain new experience by a new series of expensive trials and errors."

Trade schools make theoretical instruction of practical utility.

There are many other advantages that workshop schools have over others. Easy access to machinery, and the direct application of principles and theory learned in the school-room to work in the shops having a commercial value, would make such instruction practical in a high degree, while the tendency of the usual technological schools which use mechanical plant (generally limited in quantity) for illustration and manual

exercise only, is toward the study of science, without regard to its practical application.* Workshop schools would also make it possible to bring science to bear upon mechanical pursuits in a way and with a power that has heretofore been impracticable, because thereby it is possible to have long-continued, closely inspected and carefully verified experiments bearing directly upon practical work. So great has the demand for learning become, and so numerous and diversified the occupations of life, that to be successful it is now necessary for men and women to specialize and expend their intellectual energies in particular fields of thought and investigation. In accordance with the principle of economy from division of labor, it is necessary that the same degree of specialization shall be applied to technical education. But no school, as such, can accomplish what is needed in this direction that does not afford opportunity for practically applying the knowledge gained in class instruction, and the only way to accomplish this is to have schools intimately connected with, and under the management of, industrial corporations.†

Technical education must be specialized.

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*The great difficulty I experienced in getting tangible and conclusive evidence of the utility of workshop schools abroad arose from the *degeneration* of their original programs into purely theoretical instruction and the teaching of principles without applying them. I know of but one English school where any consistent efforts are made to apply school instruction in the shops—that of Mather & Platt, Manchester, whose teachers are employed in the shops and personally direct the theoretical instruction of their pupils to shop-work. The absence of this combination of theory and practice, under intelligent direction, constitutes the great weakness and seriously impairs the usefulness of such schools. To teach the principles of mathematics, physics, mechanics, machine construction and gearing, the formulae of chemistry, etc., without fixing those principles in the scholar's mind by illustrative experiments, the actual handling of apparatus, machinery and tools, is an impractical method of instruction which, as aforesaid, has in a large measure destroyed the usefulness of technological as well as of public schools.

†In the October *Century*, President Gilman, of the Hopkins University, places himself on record in favor of industrial education, and formulates his views of what may be done for its promotion in our educational institutions of every grade. Doubtless Baltimore would receive wise counsel and substantial aid from him and his experienced coadjutors in remodeling our school system so as to make it more nearly conform to the recognized needs of the city and age. The Guilds of

Trade schools are especially valuable for training the young of our industrial classes, because they are thereby enabled to earn a livelihood while acquiring theoretical and practical knowledge, *pari passu;* each supplementing and assisting the other. As no boy can well acquire the manual skill of a good workman except in the workshop (or in the field, so to speak), where all the details and appliances of a trade are regularly used, and where the methods and processes of that trade are to be seen on a business scale, so no boy can well acquire the theoretical knowledge pertaining to a trade where his attention is constantly distracted by material sights and sounds, more attractive to the young than mental application. We all know that scientific principles are easiest fixed in the mind in youth, and by the illustration and practice of rules in actual work, to which the responsibility of value attaches. When a boy can be got to comprehend the elementary principles of a science, he has put himself in the way of mastering that science in after years. But before he can make any solid advance in scientific knowledge, he must have a basic education such, for instance, as should be furnished by our grammar and higher public schools.*

Trade schools enable the young to earn their livelihood while being educated.

London afford valuable precedents and a wide experience upon which to found an intelligent and practical scheme of trade education; and should the city show such a spirit of advancement, the Johns Hopkins University might be disposed to supplement it with a school of applied science similar to those of Harvard or—better, because more practical—of Cornell or Columbia.

* He who has studied, reflected, learned and arranged his knowledge in system and order, is able to gather other stores of knowledge and add them to those already acquired. In order to knowledge, therefore, reflection is indispensable.

The reflective faculties, we see, are eminently practical. They are not so much for speculation as for life. Not even the simplest work can be well done without them. The chief difference in all workingmen is that some put their brains into what they do, others do not. It is so with woman's work, too—with sewing, housekeeping, cooking. How invaluable is thought in all this, and, alas! how rare. That is why we say, "Let boys and girls in our schools be taught to think; let them not be drilled so much in remembering as in reflecting; lay more stress on processes than on results." There is an objection often urged against these higher reflective faculties in their exercise for common objects—that they give theoretical rules which are not practical. Thus, if one

Even where it is not deemed wise to inaugurate workshop schools, as such, much can be done by managers of railroads towards securing higher grades of apprentices and helpers, by fixing a proper standard of qualifications, to which all boys applying for service must, as a condition precedent to appointment, demonstrate they have attained, and then requiring them to attend evening-class instruction of a technical character, which can be maintained at trifling cost, or even to attend public evening schools.

Wisdom of requiring of applicants for apprenticeship a high standard of qualifications.

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not actually engaged in teaching suggests any new view intended to improve the processes of education, he is apt to be told that this is not "practical." It is sometimes even assumed that theory and practice are opposed to each other. We often hear it asserted that a notion may be "true in theory, but false in practice"; that is, useless for practical purposes. I, for one, esteem practice. I trace all real knowledge to experience. I care for no theories, no systems, no generalizations, which do not spring from life and return to it again. Practice and theory must go together. Theory, without practice to test it, to verify it, to correct it, is idle speculation; but practice without theory to animate it is mere mechanism. In every art and business, theory is the soul and practice the body. The soul without a body in which to dwell is indeed only a ghost, but the body without a soul is only a corpse. When the waterworks in my house get out of order I want a theoretical plumber as well as one who is practical. I want a man who understands the theory of hydrostatic pressure; who knows the laws giving resisting qualities to lead, iron, zinc and copper; who can so arrange and plan beforehand the order of pipes that he shall accomplish the result aimed at with the smallest amount of piping, the least exposure to frost, the least danger of leakage or breakage; and this a merely practical man, a man of routine, cannot do. The merest artisan needs to theorize—*i. e.* to think—to think beforehand, to foresee; and that must be done by the aid of general principles, by the knowledge of laws. An intelligent man, a man of general culture, whose mind has been quickened with ideas, will often be able to show a mechanic how to do his own work. When we are young, we have a superstitious faith in the knowledge each man is supposed to have of his own business. We outgrow this after a while. If you wish anything done about your house, send for a mechanic; but overlook him: do not leave him to himself. You will presently find that you can suggest something to him in his own work which he has never thought of. All success depends on practice, but all improvement on theory. Let neither despise the other. The saying that anything "is true in theory, but false in practice," involves an impossibility. The theory indeed may be plausible, but false, and then it will not work, and its not working is the proof of its being false. It is neither true in theory nor in practice. On the other hand, a theory which is true may not work at first, because the true way of working it has not been found out. It is not false in practice, but practice has failed at first; but you cannot say they were "true in theory, but false in practice." They had not been really put in practice. If anything is seen to be certainly true in theory, it will come right by-and-by in practice. Fulton's steamboat would not work at first, nor did Stephenson's locomotive, nor Daguerre's sun-painting, nor Morse's electric telegraph; and no doubt a great many people said, "Oh! that's true in theory, but false in practice."—*J. F. Clarke in "Self-Culture."*

The good effects that have followed such a procedure have been shown in preceding pages. Mr. Thomas Clegg, of Manchester, testifies in the same strain:

"I have, from quite a boy, attended and taught night schools, and seen a good deal both of the working and results of them, and believe my convictions have arisen partly from this, and in a great measure also from being a considerable employer of workpeople; from fifteen years of age probably never having fewer than one hundred under my individual management. My two brothers and myself have now probably not less than from 1200 to 1500 people in our employ. I have always maintained against all my friends that those parties that have been educated in the schools that I have been connected with will always do *more work* for the *same money* and *do it better* and *with less trouble* than those that are not educated; and I have always been in a position to prove it so."

The system of examination of applicants for apprenticeship inaugurated by the Baltimore and Ohio Company nearly two years ago, was regarded as a hardship by many people, and especially those who had uneducated sons they wished admitted to the Mt. Clare shops. They did not consider that with lack of intelligence is always combined an absence of ambition on the part of a boy to make anything more than an ordinary mechanic of himself; that much more time is necessarily consumed in teaching a trade to an uneducated boy than to an educated one; that the former is not nearly so useful during apprenticeship as the latter, and that when he has acquired the manual skill of his trade, the uneducated workman will still be the less useful of the two, because lacking those valuable habits of careful observation and systematic thought that result from scholastic training, and are hardly ever otherwise acquired.

Examination of applicants for apprenticeship in B. & O. service.

Upon the inauguration of compulsory class instruction at Mt. Clare, the same sort of protest was freely indulged in by opponents of the measure, who argued that corporations have no right to compel their apprentices to attend evening school after a day's work, and that anyhow the results of compulsory attendance would be disappointing; for although boys might arbitrarily be compelled to attend

Compulsory instruction of apprentices in B. & O. service.

evening classes, they could not be made to learn against their will. The answer was made to such arguments that it is a common practice with firms and corporations elsewhere to compel the attendance of their apprentices at evening schools; that where applicants for apprenticeship understand this to be a condition precedent to their employment and yet accept it, there can be no injustice in enforcing the rule; that experience has shown that though boys may at first attend class instruction reluctantly, they usually soon become interested in their studies and unwilling to give them up, and that those who obstinately refuse to learn always turn out to be poor workmen, whose services are unprofitable and should, in the interest of the service, be dispensed with. The results of class instruction at Mt. Clare have abundantly demonstrated the correctness of this position.

Influence of skilled and educated workmen upon other workmen.

It may with much reason be expected that the good resulting from workshop schools will not be wholly confined to their pupils, but that their influence will extend to the journeymen and others with whom the students associate. The educational influence of a number of specially skilled mechanics upon the larger mass of workmen surrounding them will be great; their superior skill and zealous interest will inspire those who witness it with a desire to improve, and this influence will spread and perpetuate itself. That the industrial interests with which they are associated will be promoted by their correct and accurate methods cannot be doubted.

While the reasoning and illustrations in the preceding paragraphs refer especially to mechanical pursuits, they apply with equal and in some respects with greater force to other branches of railroad service.

In short, I thoroughly believe that the greater efficiency

which a railway would soon secure over its entire system through the study and application of scientific and economic principles having a direct bearing upon its various departments, would make a technological school specially designed to meet its requirements far more profitable than any other investment of the money that would be required to conduct it.* As our railroad shops are now conducted, there is little or no systematic instruction of apprentices, and, as a rule, it would be difficult to find in such shops foremen capable of giving scientific instruction, even if they had the time and inclination. But through the agency of such schools as herein described our shops would eventually be supplied with competent foremen, and a spirit of progressiveness and healthy emulation would gradually permeate the whole service. I do not doubt but that if our American employers could be brought to realize the value of such schools, they would follow the general European custom of requiring, as a condition of indenture, that apprentices should attend shop or other night schools, and this simple requirement would result in a practical educational movement the beneficent effect of which upon the nation's industries and prosperity is now incalculable.

Technological instruction in railway service a profitable investment.

All apprentices should be required to attend school.

* Answering by letter an inquiry Mr. Coler made of him concerning the economic value of workshop-school facilities to railroads. General Manager Webb, of the London and Northwestern Railroad, whose shops are at Crewe, among other things says:

"The provisions under this head (theoretical workshop instruction) are very much appreciated, as you will doubtless notice by referring to the Annual Report which I had the pleasure of handing you when here.

"With regard to the economic results, there is no doubt that the railway company, by supporting such an institution, are able to retain the services of thoughtful, steady men in their employ, not only for their own sakes, but it supplies an educational medium for their boys; and, also, the theoretical instruction imparted, if only to the comparatively few, must have some effect on the intelligence in the shops, which has been found to be the case. Many of those who have received instruction in our classes have, through their application, been intrusted with work in the engine-works requiring mental exercise who would otherwise have been still at the bench.

"This, I think, is, in an economic view, an advantage to the employers, as it does not necessitate their going outside, and consequently giving high salaries to persons required for such employment."

Railroad business grown beyond rule-of-thumb management.

In the preceding pages of this section it has been shown that, while, in its early history, the railroad business of this country was conducted with fair results by officers and employes who, of necessity, had no previous technical training or experience, but who absorbed practical knowledge as the business expanded, it has now grown to such vast proportions, both as regards its physical operations and its executive management, as to call for great skill, thorough training and broad experience in its operating officers and, in a less degree, also in the rank and file from which they are drawn; while of its executive, administrative and traffic officers it demands a varied and comprehensive knowledge and executive ability fully equal to what is needed to secure success in any other profession. It has also been shown that, generally speaking, our railroad officials have reached their present positions through successive promotions *in grade*, as the result of long experience and service; which, however, was acquired at the expense of culture equally necessary and important in, at least, those who come in contact with the public. Also that in the active competition between rival corporations, those which earliest recognize the necessity for high-grade talent, and provide accordingly, secure direct and material advantages over those that do not.

Progressive promotion in railroad service desirable, under civil-service rules.

On the ninetieth page of this report I expressed the desire to see the Baltimore and Ohio Company which, admittedly, holds a progressive position among American railways in respect to its treatment of employes, inaugurate what is familiarly known as a civil-service policy—believing that thereby it would secure greatly increased efficiency and net results. Since penning that paragraph there has been brought to my attention an article in the *Railway Review* of October 25, 1884, on the subject of

PROGRESSIVE PROMOTION BASED ON QUALIFICATION AND MERITORIOUS SERVICE, AS WELL AS ON LONGEVITY, which so fitly supplements what has been said respecting the education of railroad apprentices and employes of higher grade, and rounds off this section so harmoniously, that I quote it at length. In my judgment, however, it would be a fruitless task to undertake to inaugurate such a system of progressive promotion among the rank and file and subordinate officers now in our service,—the basic material for such a program not existing therein; but I think that the system of technological instruction of apprentices and railway cadets inauguarated by your circular of January 15, 1885, if carried to its logical sequence, would soon develop that material in abundance.

Extract from article on promotion based on meritorious service.—*Railway Review*, Oct. 25, 1884.

The knowledge and ability with which railroad officials of to-day perform the many responsible duties that now devolve upon them are mainly the result of long experience in the service. Such knowledge as this cannot be acquired from books (useful as good books are to every man); the railroads cannot look to any institutions similar in nature to law schools or medical colleges to furnish them the necessary supply of competent and efficient officers. Without the slightest desire to reflect in any way upon colleges or technical schools, it is maintained that but a small proportion of railroad officials or employes (excepting those connected with the engineering department) now or in the future will have more than a good common-school education [unless given by railroads themselves]. The time necessary to secure any better school-education than this can probably be spent to better advantage in obtaining that knowledge of details that can only be acquired by actual service in minor positions.

Accepting the foregoing as correct, it can be safely assumed that the railroads will have to look to their own ranks for their officers of both high and low degree. If this is so, it is clearly to the interests of the railroads to do all they can to elevate the standard of railway service.

So much for the general railway service of the country. And now to come down to the relations that should exist between the individual railway companies and their employes.

If the railway officials of the country must be taken from the lower grades of service, and it therefore is to the interests of the railway system to endeavor to keep the supply of competent men equal to any probable demand, is it not judicious for every railroad company to have among its own employes trained men who are familiar with its own peculiar mode of management, in order to meet any emergency which may arise?

The foregoing has not been written simply to show that it is to the interest of the railway companies to do all they can to promote the efficiency of the service, but to demonstrate that there is a certain identity of interest which should act as a bond between them and their employes, securing to one faithful service and to the other considerate and equitable treatment. The interests of the two are so closely allied that any permanent benefit to one of the parties must necessarily

be to the advantage of the other. It is to the advantage of the railroad company that its employes should serve it faithfully; it is to the advantage of the employe that his services should be considered valuable. But, to stimulate the ambition of any man, an incentive is required. No man will specially exert himself or endeavor to increase his usefulness to his employer unless he feels satisfied that at some time he will reap some reward for his increased exertions. Why should he? As a matter of fact, without such assurance his services are more likely to deteriorate; he will perform his duties in a perfunctory manner, perfectly satisfied so long as he escapes dismissal. But, on the other hand, let him see that his initial efforts at improvement are recognized, and he is stimulated to still greater efforts.

The railroad service is like an army: while every private cannot, of course, become a general, if he is entitled to promotion by reason of his personal merits he should be made a corporal, at least, on first opportunity, or in some other way receive due recognition for his meritorious conduct. Again, every recruiting officer likes to secure first-class recruits; but to do this he has to show that the service for which he desires to obtain their enlistment possesses special attractions. Now, considering the railway service to be like an army, in what way shall it show its appreciation of meritorious conduct of its employes, and what special attractions must it present in order to secure the enlistment of first-class material?

Permanency of employment is what every workingman desires. Therefore, every employe should have good reason for feeling confident that so long as he performs the duties of his position in a conscientious and faithful manner he is secure in his position; that he need have no fear of dismissal excepting for good and sufficient cause. What the railroad companies should endeavor to impress upon the minds of all employes is, that in entering the railway service they have adopted a permanent occupation in the same sense as a physician or lawyer adopts his particular profession—as a life-work, in which, under ordinary circumstances, he must expect to attain whatever success in life it may be his good fortune to have allotted him. As far as practicable, officials should discourage the employment of any one who is only desiring to secure temporary employment, while awaiting a more auspicious opportunity for engaging in some other pursuit. This class of men are of no practical benefit to the service, as they have no desire to become acquainted with the business; and if they had, would be likely to leave the service before they had acquired even a limited knowledge of their duties.

However, to induce any man to enter the service with the intention of making it his business during life, something beyond the mere fact that he will probably have permanent employment is needed. He must not only feel assured of permanent employment, but he must also be satisfied that he will be likely to better his condition as he becomes more familiar with the business, and when, as a natural consequence, his services are more valuable. Any bright and intelligent young man, full of energy and sanguine to the highest degree, is very likely to think that if his first position in the service (which, in consequence of his lack of experience and technical knowledge, must be a minor one) is to be the one in which he is likely to remain for a long period, and that he stands but a slight chance of advancement, whatever his merits may be, he had better start in some other business which presents better promise of future personal advantage. In his inexperience of the vicissitudes of life, and his unlimited self-reliance in his own natural ability, he is fully convinced that he is predestined to attain success in *something*, although he has but a very hazy idea of what that *something* is to be. But let him have reason to believe that there is a very fair probability of his securing advancement in the railroad service, if he is willing to work for it and merit it, and in his confidence in himself he will be willing to enter the service and anxious of having an opportunity of proving his ability.

For these reasons—to encourage present employes and to attract the right

kind of material to the service—it is very desirable that all vacancies that may occur in any company's service should be filled, as far as practicable, by the promotion of worthy employes from lower positions, instead of giving the position to any outside party, or to some favorite of the higher officials. Let it be fully understood by any company's employes that all vacancies will be filled from their own ranks, and that no favoritism or partiality will be shown, the appointments being made on the strict merits of each particular case, and the result will in all cases be beneficial. Of course, even when the vacancies are filled in the way suggested above, there will be more or less dissatisfaction on the part of certain disappointed employes, who think that they are the best entitled to the promotion; still, if the promotion is justly made, this will be soon recognized by all the other employes, and will have the effect of securing for the railroad management the confidence and esteem of its subordinates.

It must be admitted there are often cases where, in order to secure some particular party who is exceptionally qualified to meet the requirements of the position in which the vacancy exists, it is necessary to go outside of the company's own staff to make the appointment; but, while this for a time will cause considerable feeling, if the appointee possesses the special qualifications with which he has been credited, the fact will eventually become so patent that even the greatest soreheads will have to admit the wisdom of the company's action. However, cases like the one just mentioned are comparatively few; and if each company will make the proper efforts to increase the efficiency of its own employes, they will become still fewer.

While it may be impossible to lay down a fixed rule as to how promotions should be made which would apply to all cases and that would be just under all circumstances, a general outline of some of the principles which should govern can be given. Mere length of service cannot be taken as the only consideration which should determine what employe should be appointed to fill the vacancy; although, everything else being equal, seniority of service should have the preference. It is an undoubted fact that all men do not possess the same natural ability, and do not acquire a thorough knowledge of practical details with equal facility; and it is therefore often necessary, in order to do justice to the interests of the employer, to promote one man over other employes whose term of service has been much longer than his. The equity of this must be admitted by every one who is willing to view matters in their proper light, and so long as the promotions are fairly made from the ranks of the employes, they will not, or at least should not, complain.

Let any company adopt this policy, and select its engineers from its best firemen, conductors from brakemen, station agents from clerks, track overseers from section men, and so on through the different branches of the service, and its general officers from officers of lower grades, making each appointment purely on the plain merits of that particular case, and it will have adopted a policy that cannot fail to result in a permanent elevation of the standard of all grades of employment; which fact will be fully proven by the consequent increased efficiency of the management.

TECHNICAL INSTRUCTION IN THE BALTIMORE AND OHIO RAILROAD SERVICE.

Success of B. & O. Co. achieved despite the educational deficiencies of its rank and file

The commercial success achieved by the Baltimore and Ohio Railroad Company has in no sense resulted from the superior skill or intelligence of its subordinate

officials, or of the rank and file in its several departments, but rather in spite of their deficiencies and through the force of character and capacity for affairs of its executives and staff. It is interesting to speculate upon the greater results that might have been accomplished had the executive ability, energy and money expended to secure its present position been supplemented by a corps of officers and operatives whose general education had been of a high order, and had been supplemented by technical training such as makes original thinkers.

Extent of B. & O. mechanical operations.

In the B. & O. service there are now more than 24,000 operatives. The rapid extension of our lines, and the more than correspondingly rapid development of the Company's business, will make it necessary to largely increase this force from year to year. Referring to what has already been said on the subject of railroad companies manufacturing from raw materials, I invite your attention to the fact that of this force, about 8,000 men are engaged in the transformation of crude materials into rolling stock and other railway appliances or in their repair. I assume that the present policy has been found wise and satisfactory, and that the Company will hereafter do a still larger proportion of its own manufacturing and continue to do all its repairing. Under these circumstances the improvement of our mechanical force, as well as of the machinery in our shops, is a subject well worthy your most earnest consideration.

Explains why the rank and file of B. & O. R. R. have less education than employes of most other roads.

The fact is that the Baltimore and Ohio Railroad Company has been peculiarly fortunate, in the sense that the geographical isolation of its main stem and branches has resulted in the gradual formation of a corps of operatives who, by descent, tradition and personal attachments, may be said to belong to the Baltimore and Ohio. These people are *sui generis*. From their earliest youth they

looked forward to an active participation in the operations of the road as a means of livelihood, and all their aspirations and ambitions are associated with its service. This condition has been fostered by the custom, which for many years had the force of unwritten law, and which at the inauguration of the Relief Association was enacted into corporate law, by the official pledge of our President and Board of Directors to regard the children of meritorious employes as entitled, by right of their parents' faithful service, to priority of appointment, other things being equal, to all positions in the Company's gift. This promise has been reiterated and confirmed by yourself, by giving exceptional privileges to the families of employes, such as reduced rates of transportation, recognizing their applications to fill helpers' and apprentices' positions at all points on our lines, free tuition in the preparatory classes at Mount Clare, etc., as well as by your contemplated action in connection with the Mount Airy Home. Undoubtedly all this has resulted in creating and maintaining a corps of operatives of exceptional devotion and loyalty, and has in many other ways advantaged the service; but it has also, in some ways that were unforeseen, proven prejudicial to the Company's interests. For example, it is well known that the inhabitants along our main-stem divisions are disgracefully destitute of educational facilities, and this, coupled with the aforesaid sense of proprietorship in all minor positions in the service, with the prevalent idea that any education or knowledge beyond the bounds of his trade is of no practical use to a mechanical workman, and that an uneducated boy makes just as good if not a better mechanic than one who has an education, has created an indifference as to whether their children get even such elementary instruction as may be at their command, and

is fatal to the future of boys, especially; who, inheriting the same pernicious belief, combine with it a natural disposition to have a good time when the day's work is done. It was an understanding of this condition of affairs that prompted Mr. Cowen to make the appeal quoted on the first page of this Report, and that finally led to the establishment of the preparatory school at Mt. Clare.

Results of investigation into educational qualifications of B. & O. apprentices in 1885.

For several years prior to the issuance of your circular of January 15, 1885 (Exhibit A), the claims of each applicant for apprenticeship and helpers' places at Mt. Clare had been passed upon by a board of high and intelligent officers of the Company, and those selected on the score of fitness and merit, as well as to reward long and faithful service of their parents, were supposed to have materially elevated and leavened the younger element in the Mt. Clare shops—and, so far as I have learned, had done so. Yet, when I inaugurated a series of examinations not more difficult nor more technical than those which test the fitness of children to enter the grammar schools of most of our Northern cities and towns, it was ascertained that out of one hundred and forty-seven apprentices then in service, not one was able to pass those examinations, even after due warning and reasonable preparation. These examinations (the character of which is indicated by questions given in Exhibit X) developed the fact that a majority of our apprentices could not have entered an intermediate public school in —say—Washington, where the standard is certainly not too high; and yet the education of our Baltimore apprentices may, with reason, be assumed to be higher than that of the other apprentices scattered among the shops along our main stem and its branches, where school facilities are meagre and unsatisfactory. Our service is filled with men who must have been boys of just the type I have described, and I

think you will not fail to perceive the gravity of this statement, upon recalling the testimony heretofore presented of the serious loss and other disadvantages of employing ignorant labor, and reflect upon the further fact that, where tastes for reading and study are not cultivated in youth, they are seldom acquired in later life by those engaged in manual occupations. In proof of this, I cite the fact that, though there is a commodious library and reading-room at Mt. Clare, fairly equipped with works on science and industrial mechanics, and where all the important scientific journals are displayed for the especial benefit of our employes, the record shows that, during the past year, out of an average of 3,000 workmen at Mt. Clare, fewer than 50 visited the library at all, and fewer than 15 utilized these journals; thus conclusively showing that they have not sufficient education to appreciate these valuable means of further improvement. Out of 16,120 books circulated during the year, but 1,816 were of a strictly educational character, and they were almost exclusively drawn out by young men and boys attending our class-instruction. A very careful canvass last year demonstrated the fact that among this great mass of labor only one man subscribed to a technical journal, and that man was an ordinary mechanic. A logical deduction from this record is that our people have little or no knowledge of current improvements or of the results of scientific investigations of mechanical subjects and, as a rule, they only know methods crude and generally obsolete elsewhere, and observation confirms this.

Failure of Mt. Clare employes to utilize educational facilities at their command.

If the foregoing statements satisfy you—as I thoroughly believe myself—that it would have been greatly to the advantage of our company if not only its apprentices and journeymen, but also many of its officers, had received a

Necessity of educating B. & O. employes increased by present and contemplated extensions.

scientific education, or at least a liberal technical training, my object will have been accomplished, and it will only remain for me to point out that what is true of the past has greater force as regards the future, by reason of the extensions and expenditures that are so rapidly expanding our system, and to suggest such a program for technological instruction in our service as will commend itself to your judgment.

TECHNOLOGICAL SCHOOL AT MT. CLARE.

History of technical instruction at Mt. Clare.

On the 15th of January, 1885, you issued an Executive Order (No. 6) providing for the school-instruction of the apprentices at Mt. Clare and other Baltimore and Ohio shops in Baltimore (Exhibit A), and making an appropriation for that purpose.

Prior to the establishment of school-work at Mt. Clare, the Baltimore and Ohio apprentices had neither incentive nor opportunity to develop into intelligent workmen, so that on starting the classes it was with great difficulty and only by absolute compulsion that the attendance of about forty shop-boys was secured. They were, with few exceptions, rude and almost unmanageable in the class-room, uninterested in the instruction, and scarcely able to await the hour of dismissal, when they would vacate the school-room rudely and in haste. Then the class-instruction was confined to the most elementary subjects, and the boys were unable or unwilling to read technical or scientific books with any show of profit. Now there are under school-instruction seventy-five as orderly and polite boys as are to be found in any high school of the country, and among the very best of them are boys who a few months ago were conspicuous for rudeness and insubordination. We have had classes of apprentices in

geometry, algebra, physics, locomotive engine, mechanics, mechanical drawing, free-hand drawing, geometrical drawing, English and history, and a valuable method of instruction by special reading, selected and recommended by the teachers to each pupil, with special reference to his talents and the state of his education.*

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* Baltimore and Ohio Technological School Circular.

WHAT TO READ.

Baltimore and Ohio Employes' Free Circulating Library.

"Reading makes a full man."

This list is intended to suggest books that may be read with interest and profit by the students of the Technological School during the summer months. Other employes may, however, use the list to good advantage in choosing books for themselves and their families.

It is desired that all apprentices in the school should report, when the school opens in the fall, how many and what books they have read.

It may require an effort to become interested in some of the books named on this list, but they will, any of them, amply repay a careful and thoughtful reading, while the effort and application that are required will constitute a wholesome mental discipline. The best way to become interested in a book that at first seems dry is to read some in it every day. If, however, after giving it several days' trial you fail to get interested in it, you had better return it and draw another book; but be sure not to give up too soon.

The best way to profit by what one reads is to read little at a time, but to read often and think much. It is an excellent plan to take notes of what you read.

BOOKS OF MECHANIC ARTS AND TRADES.

Locomotive-Engine Driving; Model Locomotive Engineer; Locomotive-Engine Running; The Locomotive Engine; Catechism of the Locomotive; American Locomotive Engines; Hand Book of the Locomotive; Practical Steam Engineer's Guide; The Steam Engine; Catechism of the Steam Engine; Steam Boiler Explosions; The Boiler Maker; Use and Abuse of the Steam Boiler; Pattern Maker's Assistant; Mechanic's Tool Book; Workshop Manipulations; Brass Founder's Manual; Manual of Wood Carving; Wood Working Tools; Complete Practical Machinist; The Young Mechanic; Slide Valve and Link Motion; Road Master's Assistant; Electro Magnets; Dynamo-Electro Machinery.

BOOKS OF INVENTION.

Great Facts, a Popular History of the Most Remarkable Inventions; Industrial Biography: Iron Workers and Tool Makers, by Smiles; Edison and His Inventions; Life of Richard Trevithick, with an Account of His Inventions; Growth of the Steam Engine.

BOOKS OF SCIENCE.

How Plants Grow; Cook's New Chemistry; Wonders of Science; or, Young Humphrey Davy; Manual of Assaying; Forms of Water; Faraday as a Discoverer; The World's Foundations; Geological Sketches; Lessons in Physics; Telegraphy in Theory and in Practice; Light and Electricity; Wonders of Electricity; Lessons in Electricity; Earth and Man; Volcanoes; Health and Good Living; History of a Mouthful of Bread; The Art of Prolonging Life.

Note.—Similar lists on History, Biography, Travels, etc., etc., have been furnished scholars from time to time.

Revolution in conduct of apprentices attending class instruction.

Last year, as a rule, we had to compel boys to take up algebra and geometry; at this time many are promising promptness, regularity and other inducements to secure admission to those classes, and a number have become so urgent for higher science and mechanical studies (which the limited appropriation now at our disposal prevents us from inaugurating) as to create some embarrassment on our part, and some discontent on theirs.*

Many of these boys regularly spend their noons studying works in science and mechanics, going from shop to shop and from machine to machine, studying the principles involved in their construction and operation. Every examination for apprentices brings in a better class of applicants; as the result of which the standard upon which admission to the service is predicated is being gradually raised.

Each examination introduces a better element into the service.

I have used this home illustration to show that, while it is true you cannot force a boy to learn (for education is a growth that comes from within, and no amount of compulsion or outward pressure can directly force profitable results), yet, where instruction is intelligently conducted, voluntary interest on the part of scholars and speedy improvement are almost sure to follow. The rapid advancement of the apprentice class at Mt. Clare, in point of

Results of compulsory instruction of apprentices

* This is partly due to the fact that the classes in mechanics and physics are very interesting, and many apprentices who were not allowed to enter them until they acquired a certain perfection in algebra and geometry, have been promised technical and scientific class-instruction next year if they achieve that proficiency. We have had no trouble in interesting boys in drawing, because they, in common with other workmen and the foremen at Mt. Clare, recognize its direct help in their trades, and a strong sentiment at Mt. Clare has always favored that department of the school. The same sentiment is just as strongly against the teaching of mathematics, pure science, etc., doubtless because the direct influence of such studies upon their interests is not perceived. When, however, mathematical and scientific studies are associated with class-instruction in such technical subjects as the locomotive engine, steam, workshop appliances, methods of working iron and steel, and kindred subjects, an immediate interest and appreciation is developed.

ability and willingness to sacrifice pleasure to strict application to study, is very marked, and sufficiently proves the foregoing assertion. This instruction, though more general and less connected than would be desirable under a permanent organization, has, in a marked degree, promoted a sentiment of regard for and interest in knowledge of the principles upon which mechanical work is based. Many who previously were content to know how to do things, are now inquiring into the reasons for what they are doing.

It is not, however, to be understood that the foregoing statements apply to all the apprentices who were in our service in Baltimore at the inauguration of instruction at Mt. Clare, or that the present classes are wholly composed of such apprentices. Of those boys examined under your order of January 15, 1885, only 40 were found amenable to school-discipline and sufficiently grounded in the common English branches to justify the hope that, with such further academic training as our facilities afforded, they could profit by the proposed technical course to the extent of even qualifying themselves for graduation as mechanics; while, as aforesaid, not one of this large class of apprentices possessed sufficient elementary knowledge to permit of his entering upon the higher studies necessary to qualify him for an officer's position in the service. It being thus manifested that we had no material from which to manufacture efficient officers, nor were likely to acquire any under the then existing system, a general order was, at my instance, issued by the General Manager, promulgating regulations for the future admission of apprentices, and prescribing the minimum qualifications of candidates; which, while neither onerous nor of a high grade, provided a sufficient foundation for the technical instruction necessary to make a fairly educated mechanic. In the

But few old apprentices found amenable to discipline and instruction.

Regulations governing admission of apprentices to service.

Lines upon which instruction has been conducted.

same general order (which had your personal approval) the lines upon which it was then and is still proposed to conduct the educational work at Mt. Clare were defined in general terms, though no provision has ever been made for commencing the higher instruction therein contemplated. This general order is quoted in Exhibit U. While, owing to the exigencies of the service, it has not always been found expedient to reject *all* applicants for apprenticeship who failed to pass satisfactorily the preliminary examination, all recently appointed at Mt. Clare have been subjected to this ordeal; the result being that the new appointees are far more intelligent, better educated and generally come from a better class than perhaps had ever before been admitted to your shops. For the reasons above given, this course has been almost prohibitory to the sons of old employes, only 32 of whom, out of a total of 95, have passed the examinations since March, 1885. The immediate effect of this is that our employes are beginning to realize that the present is to be a permanent policy, and under this stimulating knowledge they are much more generally than formerly compelling their sons to attend school. As aforesaid, the mere public announcement of the proposed technological school at Mt. Clare attracted to our monthly examinations a very superior class of young men, many of whom, having entered under the apprentice regulations, are now prepared for the cadet course as soon as it is inaugurated.

Preliminary examination prohibitory to uneducated sons of employes.

Embarrassments attending class instruction.

The capacity and the elementary knowledge possessed by the individual members of a large class of boys collected under such varying conditions as those narrated above, differs very greatly in degree, and it therefore became a serious problem how to arrange their studies so as to bring them under general class-instruction. It was clearly

futile to expect any material advancement in scholastic or technical knowledge of the mass of apprentices then in the service, and yet where so much material was going to waste it was our evident duty to attempt to enhance its ultimate value to the company; therefore, the course of instruction was framed with special reference to its practical utility in, first, advancing the entire force of apprentices within reach of its influence in their several mechanical pursuits; secondly, in advancing the theoretical instruction (as far as might be practicable with the limited means at hand) of such apprentices as past examinations had shown to be possessed of sufficient common-school education to justify the hope that, without additional school-training in academic branches, they could be educated to the standard of good officers or, at least, of first-class mechanics; and thirdly, in giving such special instruction of a higher character, as our means afforded, to those who, entering the service under the new order of things, were found sufficiently advanced to receive it with profit.

Attempt to increase efficiency of all apprentices by organizing separate class instruction for different grades.

It was deemed of paramount importance that, so far as might be practicable, the work of the school should have a direct bearing upon, and an immediate connection with, the various duties in the shops with which those under instruction were or might be charged. Realizing how materially the value even of an otherwise uneducated mechanic is augmented by facility in making and reading working drawings, an effort was made to give systematic instruction in drawing to as many apprentices as our limited number of teachers and small class-space permitted. I have already reported that this part of the teaching was well received and has been measurably successful; about 60 boys taking two drawing lessons each week, aggregating eight or nine lessons per month; and this alone cannot fail to increase their usefulness to the Company.

Direct bearing of school instruction upon shop work paramount.

It was a simple matter to provide for such academic instruction as it was deemed expedient to give apprentices, and also for the examination of those wishing to enter the service, but very difficult to devise a satisfactory yet efficient plan of shop-instruction which, while bearing directly upon the apprentices' daily duties, should not conflict therewith. As the result of repeated conferences with the General Manager and the heads of mechanical departments, a series of regulations was formulated, defining the jurisdiction of the technological instructor and the shop authorities respectively over apprentices, and promulgated by the General Manager (Exhibit V). This order was measurably effective, though, as was to be expected from a dual authority, opposition was engendered, and the instructors have not received such cordial support from some of those immediately in charge of the mechanical operations of the shops as would have made their labors effective in the highest possible degree. If you conclude to continue technological instruction at Mt. Clare, this phase of the subject will need further careful consideration and revision.

Difficulty of combining school and shop instruction without conflict of authority.

It is not an easy task to present novel educational methods through the medium of reports which cover a limited experience; while many beneficial and potent results cannot be shown at all by such means. In fact, though we see that education affects people morally, mentally and physically, and that where intelligence abounds there are prosperity, general contentment and happiness,—while superstition, perversity and dissipation are the handmaidens of ignorance,—it is one of those intangible things which, though potent in results, is not to be measured by any material standard. Still it is very necessary that you and others who may be called upon

Reports of instructors on school work at Mt. Clare.

to consider the expediency of continuing and enlarging this instruction, should thoroughly understand what has been accomplished by the expenditure already made, and perhaps I cannot give you this information more accurately than by referring to the reports of the several instructors, covering the entire period of instruction at Mt. Clare, and they are accordingly appended to this report as Exhibit W.

I think the facts shown in that Exhibit and in Exhibits U and V will convince you, or any other fair-minded man, that, despite the difficulties inherent in the undertaking itself; the misunderstandings and, in some cases, the outspoken opposition of some of our shop officials, and the educational deficiencies of the boys who were first brought under school-discipline, much absolute good has been accomplished by the tentative instruction at Mt. Clare, and that your appropriation has been well expended, with substantial benefit to the service. Had the school received that hearty co-operation and encouragement it deserved, the results would have been more tangible and far more valuable; but quite enough is set forth in these reports to prove, without the aid of testimony or the cogent arguments cited in the preceding pages, that this plan of technological instruction would, if elaborated and permanently established, be productive of economic results.

Money appropriated for Mt. Clare school well spent.

Your attention is especially invited to the dozen drawings accompanying this report, which are the work of regular apprentices, all of whom, with one or two exceptions, have entered the service since the school commenced, and most of whom are apprentices of less than a year's service. They show something of the work of one department only, but are by no means exceptional in

Instruction at Mt. Clare has developed aptitudes and has generally advanced students.

their excellence. The results of our instruction in science and mechanics, and in other branches, though less tangible, are equally as great; the former especially having developed habits of thought, observation, inquiry and definite expression that far surpass what I had supposed possible under prevailing conditions.

Results attained encourage further expenditure.

Of course much remains to be thought out and experimentally applied before an harmonious practical curriculum for a technological railroad school can be perfected; but any further money appropriated in this connection will, proportionately, be much more remunerative in valuable results than what has already been expended, and the experience gained by our teachers will enable them, hereafter, to avoid many mistakes and to master many difficulties that to the novice might seem insurmountable. It is also to be borne in mind that the preliminary work already performed in the Mt. Clare School has largely been original (for the experience of neither our universities, colleges nor technical schools could be of much service to us in combining school and shop-instruction). There were really no precedents to guide us in shaping a course of instruction for railroad shops; for while in Europe there are numerous technological schools, most of them bear on industries of a different type from railroading, and even the few that are directly connected with railway corporations have been in operation only a short time and are formulated on foreign methods and necessities, and their courses of study could not effectively be introduced in this country. It is, therefore, gratifying to be able to state that several well-known and experienced scientists and educators have expressed the view that, in many respects, the Mt. Clare School is successfully working out problems in the line of connecting shop-work and school-instruction, and the

School work at Mt. Clare original in character, and has solved problem of connecting shop work and school instruction.

direct application of the latter to the former, that no attempts had previously been made to solve.

As might naturally be supposed, the shop and class-instruction of the apprentices at Mt. Clare during the past twenty months has afforded us not only an insight into the methods of administration and practice of those works, but also a full realization of the difficulties which will be encountered in planting a permanent system of technological instruction in the Baltimore and Ohio service. In this experimental work our teachers have acquired peculiarly valuable experience and knowledge of the lines upon which that instruction, to be successful, must be conducted. This knowledge is unrecorded, and, were it certain you would continue this educational work, might profitably be incorporated in this report; but it can speedily be formulated upon call, and I therefore close this particular branch of the subject with some general considerations.

Instruction at Mt. Clare peculiarly valuable in experience of shop and school work.

What has been said in general terms as to the method of educating apprentices in the Mt. Clare shops applies with equal force to our entire mechanical department. The old system of indenture in this country involved a definite responsibility on the part of the employer for the skill of the boys who graduated from his shops, which in fact has long ceased to exist, and, generally speaking, all that remains of the apprentice system of former days is an erroneous assumption in the public mind that, at the expiration of four years' service as a so-called apprentice, a boy possesses the skill and is entitled to the compensation of a journeyman. So far as the Baltimore and Ohio Railroad is concerned, the observations of six years convince me that this term "apprentice" is an entire misnomer as applied to the boys in our shops, who

B. & O. system of apprenticeship erroneous, misleading, and inefficient.

can only be classified as "helpers" and "laborers"; for they do not receive such instruction as is necessary to make them intelligent mechanics, and though, from the nature of their work, they necessarily, in four years' service, acquire a certain amount of manual dexterity, few of them have, at the expiration of that term, attained to such a degree of expertness and general knowledge of the several branches of their trades as would justify a great corporation certifying them to the world as skilled workmen.*

Much of the light and low-grade work in the manufacturing and repair shops of a railroad can be economically and successfully performed by uneducated boys and, in an emergency, much of the current work of such shops could temporarily be undertaken by them. But mere expertness in running a few machines (which may be acquired by mere repetition), even when supplemented by manual dexterity in some branches of a trade, does not take such help out of the category of uneducated labor. Helpers and laborers only they are, and helpers and laborers they will remain to the end of the chapter, under the system of handling apprentices now in vogue in our shops. Indeed I understand that no difference in pay is maintained in our Mt. Clare shops between "helpers" and apprentices. Of course I know that it would be unwise, in the present condition of the labor market from which this Company draws its supply, to reject the services of every mechanic who did not come up to a high standard, but nevertheless the Company loses money by employing such people, and should at

Labor of boys in machine shops.

Term "apprentice" a misnomer.

* "Investigations in the shops, by conversation and observation, have developed the fact that many boys or young men had completed or nearly completed their apprenticeship in the machine-shops without being able to tell the difference between cast and wrought iron; without knowing whether steel is a native or manufactured product, and equally ignorant of many other simple, though important and significant, facts which are intimately related to their trades."—[*Vide Report Tech. School Principal, Ex. W.*]

least make a well-defined distinction between the pay and rating of a properly educated artisan and of one whose only qualification is manual skill. In order to secure substantial improvement in our mechanical service there must be a point of departure, and I think you will find none better than that here indicated.

To make a practical application of this view, I submit that no young man, whatever his length of service with the Company may have been, should receive the designation or the pay of a journeyman, until it is demonstrated by examinations, as well as by actual work, that he possesses the theoretical knowledge as well as the manual dexterity which in advanced mechanical centres is accepted as the standard of a skilled artisan. Also that the rule which requires all boys applying for service at Mt. Clare to pass an examination equivalent in grade to that which admits boys to our intermediate schools (or at the maximum to our grammar schools), shall be continued and extended over our entire system; that where the exigencies of the service require the employment of a larger number of boys than can be found qualified for this examination, all applicants shall nevertheless be examined and their status and permanency in the service thus determined. In other words, that all boys found lacking in the prescribed mental qualifications, but whose services are needed, shall be rated as helpers or laborers, on a progressively lower scale of wages than apprentices of same length of service receive; that while the sons of our employes shall still have the preference of appointment, when their education is ascertained by an examination to equal that of their competitors—*and not otherwise*, after admission their examination and scholastic records shall determine their advancement, or retention, should a reduction of force

Recommendations as to employment and promotion of apprentices.

occur. The present form of indenture of apprentices should be modified to accord with General Order No. 5 of January 15, 1885, General Manager's Office, and by further provisions that no apprentice shall be entitled to additional wages at the expiration of each year's service, until he has passed the annual academic examinations of his grade; that no apprentice shall be rated or paid as a journeyman until, in addition to completing the usual shop-course, he obtains a certificate of graduation from the journeyman's course of school-studies. The wisdom of such provisions is too patent to need illustration.

Discusses desirability of employing graduates of technological institutions in railroad service.

In this connection, it is important to recall to your mind what has been said about employing the graduates of technological institutes in railway service, because that has a material bearing upon the proposition to establish a school devoted exclusively to the education of railway officers and apprentices. At the present moment especially, our system is undergoing a reorganization, and in many respects a development, that offers an exceptionally favorable opportunity to supplement the practical experience and technical knowledge of those subordinate officers charged with the details of our transportation, mechanical and road departments, with modern practice as taught in our best technological schools. By this I mean that the selection of a limited number of technological-school graduates for special instruction in the cadet course above outlined would, at a comparatively early date, provide the service with assistant foremen, supervisors, etc., who would elevate and educate those immediately above and surrounding them, while the conservatism of their superior officers would neutralize their inexperience in technical details, temper their zeal, and reduce their theories to practical applications serviceable to the Company. While, for the reasons already

stated, it is believed the appointment of technological graduates to positions of responsibility in railway service would not prove as satisfactory as the policy of securing boys well grounded in elementary studies and then educating them as specialists in railway theory and practice, there is much that can be urged in favor of their appointment as cadets, as combining the elements of economy and immediate results which, in our present situation, commends that course to your favorable consideration. This report contains conclusive testimony as to the facility and rapidity with which intelligent technological scholars absorb and assimilate a practical knowledge of the trades and professions with which they become associated, and I think no one who has read it would doubt that this plan would at least yield a profitable return, through the elevation of the *personnel* of the service and the introduction of scientific and modern mechanical processes to our practice.

Technological school graduates would make desirable subordinate officers and teacher

To reinforce this view, let me ask you to reflect upon the results that would surely follow the assignment to each of our Mt. Clare shops, after some specific instruction in railroad matters, of one or more assistant foremen, selected from the higher graduates of our best mechanical schools. You cannot fail to realize that such a policy would soon produce a revolution in the social status and in the practical mechanical operations of those shops which would greatly advantage the service generally. Another result would be that this corps of assistant foremen and supervisors, who would soon acquire practical experience and the theories of economy which form the groundwork of your administration, would furnish just the talent now needed for teaching the younger element of the service—*i. e.* teachers combining theoretical

and technical knowledge with such experience as would give them an appreciation of the lines of instruction that would yield the most practical and economic results.

Approves continuing plan of instruction announced in January, 1885.

General Order No. 5, of January 15, 1885 (Exhibit U), though purposely made general and tentative in character, in order that we might profit by future experience, still very well expresses my judgment as to the lines upon which the proposed educational work should be conducted.

The plan outlined in that order contemplates:

Explains what plan of instruction announced in January, 1885, covers.

1. Instruction (in the apprentice class, of such boys now in or hereafter admitted to the service as can pass the examination therein indicated), of a character that will make them skilled and intelligent mechanics. Such apprentices as, in this course, developed a fair amount of ability and fidelity would, naturally, graduate into the second or Cadet class. This *first class* course should, however, provide within itself all the elements of technical instruction necessary to complete a journeyman's education.

2. The *Second or Cadet course* should also be complete within itself, and should provide such technical instruction in all the departments of railway service as would fit its students for all subordinate positions of responsibility and trust in the service—corresponding to what is known in European schools as the foremen's course of study. This course, while involving more thorough and wider theoretical instruction than the apprentice course, should, to the greatest extent possible, be framed with reference to the practical mechanical operations of the shops and of the service generally.

Unless very radical changes can be effected in the common-school methods practised in Baltimore, I apprehend that a very small proportion of the apprentice class

will be able to take this higher instruction, and that we will have to look to the graduates of technological and science schools in other sections of the country that *do* afford industrial education to their citizens, for the material to constitute our cadet class. I look with regret upon this prospect, having a strong bias towards the development of local talent; but in this connection public considerations must be made subservient to our corporate needs. The widespread interest developed outside of Baltimore in the technological work at Mount Clare, and the numerous applications for admission to that school from the graduates of technological and science schools and others of equal mental discipline, give full assurance of an unlimited source of supply, and that this class will not only provide subordinate officers in sufficient numbers to meet the utmost demands of the service, but also men whose primary education will qualify them for still higher positions.

Baltimore cannot furnish enough students of sufficient attainments to fill subordinate and other positions in B. & O. service.

3. It will be the object of the *Third or Cadet Officers' course* to give to those who graduate with honor from the second class (and who have therein shown themselves possessed of ability and educational qualifications above the average) further technical training, of a still higher and more comprehensive type, which, when combined with familiarity with the operations of the various departments of the service, will go far towards qualifying the students of that course for the highest positions in the Company's gift. To this end, opportunity should be afforded the pupils of this course, in its last year, to actively participate in the production, care, repair and improvement of railway plant and in the practical operations of the service. This could readily be done—and with advantage to the service also—by distributing these students among the several depart-

Students in cadet officers' course should be afforded opportunity for participating in railroad operations.

ments as assistants—at the same time maintaining their connection with the school for further educational purposes. I have already shown how such an infusion of new blood into our mechanical and operative departments would inure to the benefit of the Company.

In the apprentice course, school-instruction should be made secondary to shop-work, while in the higher courses shop-work should always be secondary to mental training.

Although the foregoing relates especially to instruction in Baltimore, the plan has been drafted in a more general sense, and contemplates the gradual extension of this educational movement over our entire system. While Baltimore will always be the centre of such a movement, I apprehend no great difficulty in extending the apprentice course, at least, over the entire road, by establishing night-schools for drawing, mathematics, and elementary science, or securing the introduction of our boys into such schools as are already in operation, and the modification of their curriculum in the manner indicated. A cheap provision for such elementary instruction can be made by gradually transferring the young graduates from the Mt. Clare School to our divisional repair shops as assistants, and requiring them to take charge of these night-schools, and of the shop-instruction and supervision of apprentices, under a similar plan to that now in force at Mt. Clare—with, of course, such modifications as local differences and experience may suggest as desirable.

Class instruction inaugurated at Mt. Clare should be extended over entire system.

The statement in Mr. Coler's report (Exhibit W) that not one of five hundred apprentices examined in and out of Baltimore was able to pass a very simple examination, gives great force to his recommendation that the present system of a preliminary examination as a condition of apprenticeship (which has been in operation in Baltimore

Reasons why all applicants for apprenticeship should be examined.

for the past two years) shall be enforced in all the shops of our service. This preliminary examination has worked admirably and, if enforced throughout the service, will secure a class of workmen of greater intelligence than now operate your shops; and lead to improvements in machinery, economical methods of labor and avoidance of accidents. Even though you may not finally determine to inaugurate the educational work herein proposed, this system of preliminary examination should be maintained and extended as a condition of apprenticeship.

In the course of my investigation of this subject I have accumulated a large mass of data relating to the organization, management and results of technological and science schools, which it is not necessary to incorporate in this report, but which would be of material assistance should the Baltimore and Ohio Company decide to convert the present experimental teaching at Mt. Clare into a permanent bureau or department for educating officers and skilled artisans for its service. In the event of favorable action upon this school-question, I would recommend that the details of organization, the preparation of courses of study, etc., be entrusted to a commission; some of whose members should be the most experienced and successful educators that can be found in the technological field, while others should not only have a wide mechanical knowledge, combined with practical experience in the application of mechanics to those industries connected with railway service, but should likewise be thoroughly conversant with the methods and requirements of that service *as conducted in this country*. Such expert talent *can* be had and, if the subject is to be pursued at all, its importance demands that no pains or reasonable

Suggests lines upon which technological work should be conducted.

expense should be spared in getting a right start. Indeed the ultimate success of such a measure would mainly depend upon the wisdom and discretion of those who planned its details. Such a commission (aided by the local and technical knowledge of intelligent representatives of our administrative and operating departments, and by the experience of the teachers at Mt. Clare, which, in this connection, would be invaluable); performing its labors with courage, yet caution; realizing that the value and therefore the life of such a school depended altogether upon its usefulness in increasing the efficiency and economy of railroad operations, could, I doubt not, devise a system of instruction that would accomplish fully as great practical results as have ever been achieved in the field of industrial education.*

What Mt. Clare school should aim to accomplish.

The great aim of the Mt. Clare School, if it is to be maintained, should be a combination of theory and practice, by the daily application, in the workshop, of the theoretical instruction received in the school-room. I cannot impress upon you too strongly the impracticability of attempting to teach trades, or to fit youth for the practical work of life by such *theoretical instruction* and *casual* practice as are given in most of our so-called trade schools. Our Mt. Clare classes in physics and mechanics are now taught to apply principles for themselves, so far as time and apparatus will permit, somewhat after the order of the common-school instruction practised on the Continent, and described by

* Dr. Hall, of the Hopkins University, in response to a request of one of our teachers for advice on the subject of a suitable course of study for Mt. Clare apprentices, said in substance that the subject involved one of the hardest and most peculiar questions in education; that to formulate such a course would not only require an intimate knowledge of the wants of the Company and of the service of its various shops, as well as of the work and results of the leading industrial schools of the country, but would also take at least six months of his undivided time. I cite this statement of one of our most experienced educators merely to show that the subject is one of great complexity, that cannot be safely entrusted to any but the learned and experienced.

Matthew Arnold in the October number of the *Century*, and this practice has given satisfactory results, though not such as would have been secured by a cordial co-operation between the shop authorities and the school instructors. If the school is reorganized with more space and apparatus, and on a practical plan of supplementing class-instruction with work in the shop, or, more properly speaking, of systematically adapting school instruction to the current work of the shops, you will soon see a marked improvement in the mechanical operations of those shops.

I have gone into this matter at length, because it is important you should fully realize that our great want is the technical education of our people; that to educate for railroad work, even the *best* course of technical study must be supplemented with practical instruction in the workshop and in the administrative and operative offices, and that no technical course for railroad people could profitably be conducted in any school without immediate access to workshops and plant in all phases of operation, construction and maintenance; that, in its corporate interests, the Baltimore and Ohio Company could well afford to provide this practical knowledge and a certain amount of school-instruction, upon the plans outlined in connection with the Mt. Clare works; but while that plan contemplates a selection of studies from the different engineering courses in connection with other subjects that bear directly upon railroad interests, this company cannot be expected to take the place of our colleges and universities in developing special aptitudes.

What B. & O. R. R. can reasonably do to promote technical education.

I have elsewhere (pp. 77–87) alluded to the material influence which the Johns Hopkins University should —but does not—exert upon our service. I have also shown how the vital interests of the former are involved in the prosperity of the latter, and have referred at

Relationship of Johns Hopkins University to B. & O. Co. and what it should do to aid latter in its educational movement.

length to the intimate relations existing between the Johns Hopkins University and this Company. Had that intimate connection not existed, I should not have felt justified in criticising, in this report, the policy and methods of its management; but as that association *does exist in fact*, and as I consider the objects this report is intended to subserve are—in a reflex sense—as vital to the Hopkins University as to the railroad itself, I have felt as free to comment upon its methods as upon our own. The prime need of the University is the greatest attainable income from its endowment compatible with security. The greater portion of its capital being invested in Baltimore and Ohio securities, it is fair to assume that the first desire of its trustees is the permanency and commercial success of that road. The great influence of technical education upon the prosperity and net earning capacity of industrial corporations (among which must be classed the Baltimore and Ohio) is so clearly and unquestionably shown in this report, as is also the low educational standard of the community from which this service draws its main supply of labor, that it seems only necessary to point out the relations which these interests bear to each other and the need that exists for the aid which the University could so effectively give, to secure the hearty approval and co-operation of its trustees and faculty in judicious efforts to elevate our service. They are eminently qualified to appreciate the value of intelligent and scientific methods, and I need hardly point out that, as it is very doubtful if the University could get a better investment for its endowment than that it now holds in our securities, the best way to make their endowment highly remunerative and permanently secure is to follow the lines herein indicated, and that any expenditure or sacrifice they might make in this connection would be a wise insurance of their capital against depreciation.

From an outside point of view, it would seem as though so large a shareholder in the Baltimore and Ohio Company should take a more lively interest in the affairs of that corporation than it has done, and that pride, no less than self-interest, should prompt it to supplement our efforts by remodeling its curriculum so as to afford better facilities to the general public of Baltimore, and especially to those in our service who may develop a capacity for higher instruction than will be obtainable under the proposed Baltimore and Ohio program; which, while providing a very substantial foundation, cannot undertake to give advanced instruction in engineering and other higher branches of scientific and mechanical knowledge.* Certainly neither this community nor our country at large would be the losers if, in order to inaugurate such a course, it was found even necessary to curtail its present program, which is currently recognized as aiming to devote the University to original research and to finishing (in its highest sense) the education of the graduates of our other universities.

In conclusion, I beg to say that, while of course I desired and earnestly endeavored to obtain the most practical

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* That a railroad company *as such* would not be justified in furnishing means for such an extensive course as would accomplish all the objects herein viewed, and that, without public or private assistance, its efforts must at best be devoted to affording thorough instruction in those *elementary* branches which will give the most practical and immediate return to the *railroad*, is made patent by the following considerations:

Engineering, though important, is only a part of what must be taught in a course intended to fully qualify young men for the higher walks of railroad life, and yet to provide the necessary buildings, apparatus and a corps of suitable instructors to teach that branch alone, in its advanced stages, would require a very considerable annual appropriation.

In Cornell, as I am informed, the faculty of civil engineering alone includes nine teachers, while Stevens Institute, which provides only for a course in *Mechanical Engineering*, has a corps of twelve teachers, and Rensselaer Polytechnic Institute, Troy, N. Y., provides a corps of nineteen teachers for advanced instruction only in *Civil Engineering*—the conditions of admission requiring students to be well grounded in elementary studies. True, some of the instructors in Cornell teach in other departments, but then the students of engineering get part of their instruction in allied departments. A course in any one kind of engineering would require the full time of at least six teachers. To secure first-class men for these positions would necessitate a large expenditure.

What program of January 15, 1885, for educating B. & O. employes really signifies in its relation to general interests.

results for the Company, in return for its expenditures, your order of January 15, 1885, had, to my mind, a much greater significance than attached to a course of mere experimental instruction of ignorant apprentices. I clearly realized that this attempt to influence the methods and practices of a great industry, by carrying systematic mental instruction into its workshops, was really inviting a public determination of the question whether or not systematic technological instruction, under corporate auspices (*and therefore under the most favorable conditions*) was practicable; and if practicable, economical and otherwise desirable. If an experiment, conducted as this was to be, under the supervision and control of a great corporation, whose wealth, thorough organization, commercial, manufacturing and transportation operations and interests, combined with its well-known desire to elevate its employes, failed of success, no other railroad or other large industrial corporation would be likely, in the near future, to renew the attempt to graft upon our democratic institutions the system of technological instruction pursued abroad with material advantage to all concerned.

B. & O. program an entirely new departure in industrial education and work.

Another consideration which gave me great concern in this connection was that the program announced in your order was substantially novel in this country, both in respect to educational and industrial practices, in that it contemplated, on the one hand, reversing the present steady tendency of our technological and science schools towards the theoretical rather than the practical in mechanical and kindred studies, while, on the other hand, it proposed making school-instruction directly supplemental to the usual shop-work of apprentices and others—*professedly* for the purpose of elevating and diverting the mechanical and other operations of a great corporation from obsolete to modern

practice—a plan that, so far as I am able to learn, has never before been practically attempted in this country. The idea of such a school is just as new in the line of school-work and education as railroading was in the line of transportation fifty years ago. If, under this program, it could be clearly demonstrated that a bureau or department established for the specific education of railroad officers and artisans to a higher than the current professional standard was really a practicable and economic adjunct to the operative, administrative and executive departments of American railways, it would not be extravagant to hope for a general industrial educational movement, not only on behalf of the half million men engaged in railroading, but such an one as has been vigorously advocated by a large number of our wisest citizens, irrespective of class and profession, as well as by intelligent workmen in various sections of the country (*vide* p. 65). A movement that, though originated by the potent agency of self-interest, would finally reach beyond all sordid considerations and result in improving the entire mass of our laboring population, and in elevating the United States more nearly to her proper rank among the industrial nations.

What it may lead to in a national sense.

Reference has previously been made to the analogy between railroading and our military and naval services. An intimate acquaintance of many years with the details of military organization and service, and a more general yet practical knowledge of the systems under which our navy and railroad properties are operated, has perhaps specially qualified me to appreciate what is common to them all, and I have been greatly impressed with the belief that the educational measures and methods which have made our military and naval officers professionally

Analogy between the military, naval, and railroad professions.

so efficient, would prove equally efficacious if applied, with necessary modifications, to railroad service.

In closing this report it is proper to express my sincere regret that my own want of experience and fitness for the task has necessitated the preparation of such a lengthy paper, in order to intelligently place before you information that others better qualified could have more clearly and succinctly stated. On reviewing these pages, I observe that they bear evidences of spasmodic effort, and, in a certain sense, of evolution of thought, which is additional matter for regret; but the subject is of such a character as to demand for its satisfactory presentation a consecutive research and study which press of other and onerous duties altogether precluded me from giving it. The same causes operated to prevent an earlier conclusion of my task.

Length of report and delay due to pressure of other work.

In thus relinquishing all further responsibility and connection with this very interesting but exacting subject, I desire to say that, in stating facts fearlessly and expressing my own views frankly, I have been governed solely by a desire to elevate the *morale* and efficiency of the Baltimore and Ohio Railroad and its allied interests and, incidentally, to advance the industrial education—and as a necessary consequence the material prosperity—of this community.

Respectfully submitted:

W. T. BARNARD,
Assistant to President.

EXHIBITS.

Exhibit A.

BALTIMORE & OHIO RAILROAD COMPANY,
OFFICE OF THE PRESIDENT,
BALTIMORE, *January* 15, 1885.

Executive order for the inauguration of school instruction at Mt. Clare.

EXECUTIVE ORDER No. 6.—The inauguration of a Baltimore and Ohio Technological School for the promotion of a higher course of instruction for the apprentices of this service than that now pursued, with headquarters at Mt. Clare, Baltimore, and conducted under the superintendence of a board of seven directors, appointed annually by the President of this Company, is announced.

MESSRS. JOHN K. COWEN, E. J. D. CROSS, DR. CHARLES M. CRESSON, ANDREW ANDERSON, DR. W. T. BARNARD, BRADFORD DUNHAM and CHARLES SELDEN are hereby appointed such directors for the calendar year 1885.

The course and method of instruction in its several departments, and the operations of the Technological School, shall be governed by regulations prescribed by its Board of Directors.

In furtherance of the objects for which this school is founded, and to secure uniformity and discrimination in the employment of apprentices in all departments, the General Manager will promulgate rules regulating their appointment and service.

In the establishment of a technological school the Company affords the youth in its employ opportunities for obtaining a liberal technical education far superior to those enjoyed by the employes of other railroads. The examinations prescribed in the course of the Technological School will be very thorough, and will require from the apprentice a close and persevering attention to study, without evasion or slighting of any part of the course, as no relaxation of any kind can be made by the Board of Examiners; and, as the Company will hereafter endeavor to advance the graduates of the Technological School to positions of responsibility and trust in its service, only those who demonstrate willingness and ability to qualify themselves for advancement will be retained.

The General Manager will convene a Board of Examiners, consisting jointly of two medical examiners of the Relief Association and three instructors of the Technological School, whose duty it shall be to examine and classify all apprentices now in service in accordance with the standard of qualifications prescribed in his General Order on the subject. This board will visit each station where apprentices are employed, and finally report, in writing, to the General Manager the result of their labors.

ROBERT GARRETT, *President.*

Exhibit B.

Polytechnic School at Zurich, Switzerland.

The Polytechnic School at Zurich, Switzerland, is one of the largest and most successful of its kind. It was established in 1854, and the magnificent building which it occupies is one of the leading features of Zurich. Its citizens are justly proud of the noble edifice and of the great work accomplished by the school in developing their industries, attracting capital to their city, attracting hundreds of students, and sending forth trained specialists to all parts of the world, and generally in improving the condition of all classes of society.

This institution supports a large number and variety of laboratories, libraries, industrial museums, collections of apparatus, and objects of scientific and artistic interest, which of themselves exert a wonderful educating influence upon the thousands of students that resort to them for instruction and training. It

makes provisions for more than two hundred distinct courses of lectures, given by as many as sixty different professors, many of whom have a world-wide reputation in their respective departments of science. These professors are assisted in giving instruction by numerous tutors, curators of museums, and other servants employed to assist in experiments and to take care of the apparatus.

Its object and influence.

The object of the school has from the first been to impart the greatest possible amount of scientific instruction to the artisan classes, and to direct thought and scientific research to the development of industrial arts and trade. In this way there have been brought about a mutual interchange of ideas between science, and the actual application of its principles to manufactures, etc. The direct and indirect benefits thus resulting to the industries of Switzerland and Germany are numerous, and the school receives the hearty support and indorsement of manufacturers, merchants, legislators, and the intelligent citizens in general of both countries. In the most successful factories and commercial establishments of Switzerland and Southern Germany, and often in France, are found managers, foremen and leading workmen who have received their education and preparatory training at the Zurich Polytechnic University. These men have not only become experts in their special departments, as a result of their training in this school, but they have learned to study the history, progress and present condition of the industries of their own and other countries; and this knowledge is especially valuable to those whose establishments and commercial interests they conduct. Oftentimes proprietors of large establishments are themselves graduates of this school, and are thereby qualified to perform much executive labor that would otherwise be entrusted to men whose services could be secured only by the payment of large salaries.

But the influence of the Zurich Polytechnic School is not confined to Switzerland and Germany. The impetus that it gives to industrial pursuits is felt and acknowledged in more remote countries. Students come from all parts of the world to profit by the instruction it affords, and, having completed the prescribed course of study, return to their native countries to enter upon careers of industrial labor in which they fully utilize their attainments. Last year six students from different parts of North America entered this school. The English Royal Commissioners testify that in almost every country visited by them graduates of the Zurich School were found in the leading industrial institutions, or were teachers in numerous technical schools.

Exhibit C.

Technical High School at Munich.

The Technical High School at Munich is similar to the Zurich School. The magnificent buildings in which this school is conducted were erected at a cost of over $775,000, whilst the cost of its various collections exceeded $180,000, and the annual expense of maintaining the school is $100,000. This great institution was founded and is operated with special reference to the higher education of the industrial classes, and one of its notable features is the numerous subdivisions into which the various subjects taught are divided, each special branch of a subject being taught by a separate professor, who, by limiting his investigations, is enabled to master every detail of his chosen specialty. Thus in the department of engineering forty-five distinct courses of lectures are given by thirteen professors. The school is well supplied with laboratories, in which all kinds of experiments are tried, the results of which are carefully tabulated by the students and recorded in their books. The students in the engineering branch determine the strains and modulus of elasticity of different substances, make numerous tests of the various kinds of wood, stone and other building material, and carry on series of investigations to ascertain constants, to verify formulæ, and to test the strength of metals of various sections, including experiments as to torsion, tension, compression, and the effects of long-continued concussion on the fibre of metal bars.

This testing laboratory, besides having afforded instruction to hundreds of students since it was founded in 1868, has been largely utilized by numerous manufacturers and builders in all parts of Germany, who frequently send materials there to be examined, tested, and reported upon.

Notwithstanding the great capacity of this school in the way of teachers, laboratories, apparatus and class-rooms, some of the departments are overcrowded, and numerous students seeking admission are annually turned away.

Exhibit D.

Technical education in Chemnitz, Saxony.

In 1856 a weaving school was founded at Chemnitz, Saxony, by way of an experiment in technical education. Here practical weaving has been taught for almost thirty years. Mr. Felkin, who wrote a book some years ago on "Technical Education in a Saxon Town," asserted that "the school had been of great benefit to the trade of the town and district," and the British Royal Commissioners, after having visited the schools, say that Mr. Felkin's statement is corroborated by many influential citizens of Chemnitz with whom they conversed, and add that there was a general concurrence of testimony in favor of the school on the part of all manufacturers with whom they talked. The classes are attended by merchants and distributors of goods, and by the sons of manufacturers, as well as by managers, firemen, designers and other workmen. There is not a manufacturing establishment in the town that has not one or more men in its employ whose training was received in the school. Of late years English students have been attending the classes, having selected this school as the best place to receive a preparatory training for the factory. Some enterprising manufacturers from distant cities have sent their managers to take a course in the school at the expense of the firm. A leading feature of this school consists in its provisions for instructing merchants and salesmen in the quality, design and material of textile goods, so that they may be better able to buy intelligently, by detecting faults and imperfections in the nature of the goods, by judging of the merits and demerits of new designs. This feature of the school-work is sometimes opposed by the manufacturers.

So great has been the success of the school at Chemnitz that numerous other weaving schools have been established and modeled after it. Such schools are to be found at Glauchan, Meerane, Loessnitz, Oederan, Milwerda, Hainichen and Frankenberg, all of which places are adjacent to Chemnitz, and where weaving is the principal industry.

Exhibit E.

Bradford (Eng.) Technological School.

The citizens of Bradford, England, a few years ago organized a technological college adapted to the wants of the principal industries of that manufacturing centre. The new buildings were opened by the Prince of Wales in 1882, and though the original plan has by no means been perfected, the cost of the buildings and apparatus therein has already exceeded $200,000. When complete it will be one of the best institutions of its character in Europe. Concerning this institution the Royal Commissioners say: "The formation of the college was the result of the prevailing feeling in the minds of many of the commercial community at Bradford that, in the competition of the world's industries, it has become more and more needful to develop, to the fullest extent, the technical knowledge of the employers and operatives in the various industries on which the prosperity of the district depends. It was therefore determined that an institution should be founded in which instruction should be given in the principles underlying the numerous industries of the city and vicinity."

Exhibit F.

Conclusions of the British Royal Commissioners.

The conclusions of the British Royal Commissioners, as summed up in their report, though somewhat voluminous, are so thoroughly a digest of industrial development that they will certainly repay careful perusal in full by those interested in the subject; but even the *résumé* of their deductions embraced in the extracts herein quoted illustrates the value of the subject.

Extracts from the Conclusions of the British Commissioners as to the Effect of Technical Education on ndustries.

Effect of scientific and technical training on European industries.

* * * It will have been seen from the preceding pages of this report that we have attached considerable relative importance to that portion of our commission which directed us to inquire into the condition of industry in foreign countries; and it is our duty to state that, although the display of Continental manufactures at the Paris International Exhibition in 1878 had led us to expect great progress, we were not prepared for so remarkable a development of their natural resources, nor for such perfection in their industrial establishments, as we actually found in France, in Germany, in Belgium and in Switzerland. Much machinery of all kinds is now produced abroad equal in finish and in efficiency to that of this country, and we found it in numerous instances applied to manufactures with as great skill and intelligence as with us.

In some branches of industry, more especially in those requiring an intimate acquaintance with organic chemistry, as, for instance, in the preparation of artificial colors from coal-tar, Germany has unquestionably taken the lead.

The introduction by Solvay, of Brussels, of the ammonia process for the manufacture of soda, and the German application of strontia in sugar refining, constitute new departures in those arts. In the economical production of coke we are now only slowly following in the footsteps of our Continental neighbors, whilst the experiments which have been carried on for nearly a quarter of a century in France for recovering the tar and ammonia in this process have only quite recently engaged our attention.

The ventilation of deep mines by means of exhausting fans was brought to perfection in Belgium earlier than with us, and, although our methods of sinking shafts served for many years as models for other countries, improvements thereon were made abroad which we are now adopting with advantage.

The abundant water power in Switzerland and in other mountainous districts is utilized for motive purposes by means of turbines perfect in design and execution.

The construction of the dynamo-machine by Gramme gave the first impulse to the general use of electricity for lighting, and to the various new applications of that force which appear likely to exercise so great an influence upon the industry of the world; and in all these applications, at least, as much activity is exhibited on the Continent as with us.

In the construction of roofs and bridges, more especially in Germany, accurate mathematical knowledge has been usefully applied to the attainment of the necessary stability with the LEAST consumption of materials.

Progress of England's industrial system.

The beginnings of the modern industrial system are due in the main, as we have indicated, to Great Britain. Before factories founded on the inventions of Watt, of Arkwright and Crompton, had time to take root abroad, and whilst

our own commerce and manufactures increased from year to year, the great wars of the early part of this century absorbed the energies and dissipated the capital of Continental Europe. For many years after the peace we retained almost exclusive possession of the improved machinery employed in the cotton, woolen and linen manufactures. By various acts of the last century, which were not repealed till 1825, it was made penal to enlist English artisans for employment abroad; the export of spinning machinery to foreign countries was prohibited until the early years of Your Majesty's reign. Thus, when, less than half a century ago, Continental countries began to construct railways and to erect modern mills and mechanical workshops, they found themselves face to face with a full-grown industrial organization in this country which was almost a sealed book to those who could not obtain access to our factories.

Continental countries compelled to found technical schools.

To meet this state of things, foreign countries established technical schools like the Ecole Centrale of Paris, and the polytechnic schools of Germany and Switzerland, and sent engineers and men of science to England to prepare themselves for becoming teachers of technology in those schools.

Technical high schools now exist in nearly every Continental State, and are the recognized channel for the instruction of those who are intended to become the technical directors of industrial establishments. Many of the technical chemists have, however, been, and are being, trained in the German universities. Your Commissioners believe that the success which has attended the foundation of extensive manufacturing establishments, engineering shops and other works, on the Continent, could not have been achieved to its full extent, in the face of many retarding influences, had it not been for the system of high technical instruction in these schools, for the facilities for carrying on original scientific investigation, and for the general appreciation of the value of that instruction, and of original research, which is felt in those countries.

Fruitful results of these schools.

With the exception of the Ecole Centrale of Paris, all these schools have been created, and are maintained almost entirely, at the expense of the several States, the fees of the students being so low as to constitute only a very small proportion of the total income. The buildings are palatial, the laboratories and museums are costly and extensive, and the staff of professors, who are well paid according to the Continental standard, is so numerous as to admit of the utmost subdivision of the subjects taught. In Germany, as we have stated in a previous part of our report, the attendance at some of the polytechnic schools has lately fallen off, chiefly because the supply of technically trained persons is in excess of the present demand; certainly not because it is held that the training of the school can be dispensed with. The numerous young Germans and Swiss who are glad to find employment in our own manufactories have, almost without exception, been educated in one or other of the Continental polytechnic schools.

General industrial intelligence of masters and managers on the Continent.

Your Commissioners cannot repeat too often that they have been impressed with the general intelligence and technical knowledge of the masters and managers of industrial establishments on the Continent. They have found that these persons, as a rule, possess a sound knowledge of the sciences upon which their industry depends. They are familiar with every new scientific discovery of importance, and appreciate its applicability to their special industry. They adopt not only the inventions and improvements made in their own country, but also those of the world at large, thanks to their knowledge of foreign languages and of the conditions of manufacture prevalent elsewhere.

The French and German schools for miners, and the one which has been quite recently founded in Westphalia for workers in iron and steel, differ from the preceding schools for foremen, inasmuch as they are reserved for the theoretical instruction of men who, having already worked practically at their trades, have distinguished themselves by superior intelligence and good conduct. Most of the German schools of this kind are founded or maintained by the manufacturers, and will, we feel confident, repay the trades which have had the foresight and public spirit to create them, by training young men to become foremen and leading hands, willing and able to carry out with intelligence the instructions of their superior officers.

Societies for promotion of industrial knowledge.

In several of the more important industrial centres of the Continent there exist societies, such as the Sociétés industrielles of Mulhouse, Rheims, Amiens, etc., the Société d'enseignement professionnel du Rhone, which has its headquarters at Lyons, and the Niederoesterreichischer Gewerbe-Verein of Austria, one of the chief objects of which is the development of technical education among workmen and other persons engaged in industry by means of lectures and by the establishment of schools and museums of technology. These associations are supported mainly by the merchants and manufacturers of the district to which their operations are restricted. In many cases they are founded and supported, or are greatly assisted, by the Chambers of Commerce; these bodies abroad, being incorporated, and having, in France, considerable taxing powers over their members, are generally wealthier and more influential than those in our own country. In addition to these sources of income, the associations receive help from the municipality, and sometimes from the State. In Mulhouse, besides promoting education, the society sees to the material well-being of the workmen by erecting, on a large scale, laborers' dwellings (la cité ouvrière), and by organizing savings banks and other economic arrangements; undertaking, in this respect, on a smaller scale, what is done in this country by self-sustaining associations, like building and co-operative societies of the workpeople themselves. The society in Lyons has established numerous evening classes for elementary and technical instruction, which are attended chiefly by workpeople; and the South Austrian Trade Society, which has its central office in Vienna, has organized several technical day and evening schools for operatives of every grade, which are now under State control, and receive subventions from the Government.

Mr. Mather's report on United States and Canada.

The report of Mr. William Mather to your Commissioners, on his six months' tour throughout the United States of America and Canada for the purpose of studying the schools and factories of that continent, deserves the most careful perusal. It will be seen that Mr. Mather assigns greater influence on American manufactures to the general education of the American people derived from their common schools than to their technical schools, the importance of which latter, however, in the training of civil engineers, has been experienced for some years, though it has only more recently become recognized by those who are engaged in mechanical engineering and in metallurgical and manufacturing establishments of various kinds. This recognition is, however, now becoming universal. A decided preference is being given in the United States, for the positions of managers and heads of departments, to persons who have received a *scientific training in a technical school*, and the plan is followed in these schools of *combining instruction in "application" with instruction in pure science*. Although the conditions of American industry differ in many respects from our own, there can be no doubt that we may derive great advantage from a careful study of what is being done in the way of technical instruction in the United States, as, together with the elementary education of Canada, it is so graphically described by Mr. Mather. We may add that the accuracy of his statements and conclusions is generally confirmed by the accounts of technical instruction in America which we have received from other competent judges.

Not many years have passed since the time when it would have still been a matter for argument whether, in order to maintain the high position which this country has attained in the industrial arts, it is incumbent upon us to take care that our managers, our foremen and our workmen should, in the degrees compatible with their circumstances, combine theoretical instruction with their acknowledged practical skill. No argument of this kind is needed at the present day. In nearly all the great industrial centres—in the metropolis, in Glasgow, in Manchester, Liverpool, Oldham, Leeds, Bradford, Huddersfield, Keighley, Sheffield, Nottingham, Birmingham, the potteries, and elsewhere—more or less flourishing schools of science and art of various grades, together with numerous art and science classes, exist, and their influence may be traced in the productions of the localities in which they are placed. The schools established by Sir W. Armstrong at Elswick; by the London and Northwestern Railway Company

Schools established and supported by industrial corporations.

at Crewe; and those of Messrs. Mather and Platt, of Salford, in connection with their engineering works, testify to the importance attached by employers to the theoretical training of young mechanics. The efforts of Messrs. Denny, the eminent shipbuilders of Dumbarton, for encouraging the instruction of their apprentices, and for rewarding their workmen for meritorious improvements in details applicable to their work, are proofs of this appreciation. The evidence of Mr. Richardson, of Oldham, and of Mr. Mather, of Salford, is emphatic as to their experience of its economical value.

Without more particularly referring to the valuable work in the past accomplished by the numerous mechanics' institutes spread over the country, many of them of long standing, we may point out that they are now largely remodelling their constitutions in order to bring up their teaching to the level of modern requirements as regards technical instruction. The example of the Manchester Mechanics' Institute may be studied in this connection.

Moreover, as evidencing the desire of the artisans themselves to obtain facilities for instruction both in science and art, we must not omit to mention the classes established and maintained by some of the leading co-operative societies. The Equitable Pioneers' Society of Rochdale has led the way in this, as in so many other social movements. It is much to be wished that the various trades' unions would also consider whether it is not incumbent on them to promote the technical education of their members.

The manufacturers of Nottingham speak with no uncertain voice of the important influence of the local school of art on the lace manufacture of that town. Without the Lambeth School, the art productions of Messrs. Doulton could scarcely have come into existence. The linen manufacturers of Belfast are becoming alive to the necessity of technical instruction, if competition on equal terms with foreign nations in the more artistic productions is to be rendered possible. The new generation of engineers and manufacturers of Glasgow has been trained in the technical schools of that city. The City and Guilds of London Institute owes its existence to the conviction of the liverymen that technical instruction is a necessary condition of the welfare of our great industries.

Natural science is finding its way surely, though slowly, into the curriculum of our older English universities and of our secondary schools. It is becoming a prominent feature in the upper divisions of the elementary board schools in our large towns. There are scarcely any important metallurgical works in the kingdom without a chemical laboratory in which the raw materials and products are daily subjected to careful analysis by trained chemists. The attainments of the young men who have been trained in the Royal Naval College at Greenwich recommend them for remunerative employment by our great shipbuilding firms.

In our relations with public bodies and individuals in this country during the progress of our inquiry, the greatest anxiety has been manifested to obtain our advice as to the mode in which technical instruction can be best advanced, and we have to acknowledge the readiness of the Education and Science and Art Departments to receive and act upon suggestions in matters of detail from individual members of the Commission which it would have been pedantic to delay until the completion of our task. Amongst the suggestions which have thus been made was that of an exhibition of the school work of all nations, which His Royal Highness the Prince of Wales has consented to add to the Health Exhibition of 1884. This exhibition will be an appropriate illustration of the account of foreign schools contained in the previous parts of this report. Your Commissioners, during their Continental visits, received from the authorities of technical schools numerous assurances of their cordial support and co-operation in such a display.

How the cost of schools should be borne.

In considering by whom the cost of the further development of technical instruction should be borne, we must not forget that, if it be true that in foreign countries almost the entire cost of the highest general and technical instruction is borne by the State, on the other hand, the higher elementary and secondary instruction in science falls on the localities to a much greater extent than with

us; whilst, as to the ordinary elementary schools, the cost in Germany and Switzerland is almost exclusively borne by the localities; and this was also the case in France and Belgium until the people of those countries became impatient of the lamentable absence of primary instruction on the part of vast numbers of the rural, and, in some instances, of the town, population; an evil which large State subventions alone could cure within any reasonable period of time. With the exception of France, there is no European country of the first rank that has an Imperial budget for education comparable in amount with our own. In the United Kingdom at least one-half of the cost of elementary education is defrayed out of Imperial funds, and the instruction of artisans in science and art is almost entirely borne by the State. Hence, it will be necessary to look, in the main, to local resources for any large addition to the funds required for the further development of technical instruction in this country.

Educational value of museums.

We cannot dismiss this branch of the subject without calling attention to the educational value of the museums of natural objects now found in many of the modern elementary schools of the Continent. Probably the best examples of such collections are those of the Normal School of Brussels, and of the elementary schools of Zurich. Collections of natural objects, pictures and diagrams are of the greatest assistance for illustrating object lessons in rudimentary science to children of the earliest years.

Free libraries.

Many persons who have paid attention to the working of free libraries in our large towns, are of opinion that the benefit of these might be extended to elementary schools by placing at the disposal of such schools books of a character calculated to interest children of school age. Amongst these books some suitable technical works, especially illustrated ones, might be included. These school libraries would be of the nature of the branch libraries which are now attached to many of the free libraries of our large towns.

Manual training as a part of school work.

Your Commissioners, after having had the opportunity of further considering the value of manual work as a part of primary instruction, and after having seen such work introduced into elementary schools of various grades in other countries besides France, are able now to express a stronger opinion in its favor than at the time of their first report. They do this with greater confidence because, in consequence partly of the suggestion contained in that report, the experiment of introducing manual work into primary schools has been successfully effected by at least two school boards in this country—viz.: those of Manchester and Sheffield. They have had the opportunity of inspecting the manual work of the pupils both at the Manchester Board Schools and at the Central School in Sheffield, and they are satisfied that such work is very beneficial as a part of the preliminary education of boys in this country who are to be subsequently engaged in industrial pursuits, even though it should not, as, however, it probably will do, actually shorten the period of their apprenticeship.

Exhibit G.

ENGLISH SCIENCE SCHOOLS AND THE CITY AND GUILDS OF LONDON INSTITUTE.

English technical schools.

The English Government is beginning to make liberal provision for the higher training of artisans. Its great international exhibitions have served to arouse a spirit of national pride among the English people. They have seen themselves outstripped in the race for national supremacy in articles of manufacture, but they are resolved to regain their former prestige as a nation of first rank in art. This spirit of national pride, combined with that indomitable enterprise which is so characteristic of the English race, and which is just now quickened by the depression in trade and the intense rivalry that results from sharp competition with Continental nations for control of the great industries and home and foreign commerce, together with the necessity of making some provision for the employment of the thousands of men and women who are dependent upon their daily

earnings for their livelihood, and of making such a disposition of the children of those people as will prevent their becoming paupers, vagabonds and criminals, has taken a practical turn by endeavoring to place the means of acquiring a special training for some field of productive industry within the reach of all. But the English Government does more than merely provide schools and apparatus. It has a great university of science and art at South Kensington, where the ablest instructors that the nation has produced are employed and furnished with every needful facility to train special teachers for the highest departments of artistic manufacture, and for the various schools of industry that are being established in every industrial centre. The Government also holds out inducements in the way of prizes and scholarships as incentives to young people to enter the schools and complete the prescribed courses of study.

South Kensington science and art schools.

The great tendency of the Government schools, however, is to provide for the teaching of pure science only, or of applied science only in a theoretical way. To supplement this theoretical instruction by making a direct application of the science thus taught to the development of the numerous national industries, efforts have been put forth in various directions to provide for a corresponding development of skill by training the hand, the eye and the taste of persons engaged in manual pursuits. The greatest of these attempts is the one that has been made by the numerous guilds of London. These organizations have been accumulating great stores of wealth for several generations, and of late years they have wisely determined to utilize their hoarded treasures by establishing and sustaining schools for both the secondary and the higher training of people who, like themselves, are engaged in industrial avocations. Accordingly they have formed what is known as the City and Guilds of London Institute, the purpose of which is to provide for and encourage education adapted to the requirements of all classes of persons engaged, or expecting to engage, in manufacturing and other industries. Recognizing that the teaching of pure science is so extensively provided for by the Government, this Institute makes no attempts in that direction, but confines its efforts to technical education in the true sense of that expression —*i. e.*, the development of skill and the acquisition of manual dexterity in industry —by uniting manual training with science teaching, and basing all shop instructions upon scientific principles.

City and Guilds of London Institute.

The guilds are organizing a number of technical schools in various parts of London for the education of the artisans of the great metropolis, and to serve as models of schools to be founded in other cities and towns of the kingdom. These schools are to be supported in part by fees and local efforts, and in part by grants, conditioned on results, from the Government and from the guilds. The Institute also aims to induce existing educational institutions to make provision for technical education, and they make yearly grants to these institutions, providing the education they furnish is of such a character as to satisfy the Council of the Institute. When the existing institutions make provisions sufficiently varied and extensive to meet the requirements of a community, the guilds make no effort to establish a separate school there.

The guilds also encourage the formation of evening classes, in which boys and men engaged in the performance of their duties during the day receive special instruction in the principles of science, and in the application of these principles to the various processes that engage their attention in the shops and factories. They now assist in the support of evening classes in technology, as distinguished from the Government classes in science and art, in nearly all the large centres of industry.

The guilds of London have also established, and propose to maintain, a great central institution at South Kensington, near the National Industrial Museum and the South Kensington School of Science and Art. This central institution is similar in many respects to the polytechnic schools of Germany, Switzerland and Italy, and to the École Centrale of Paris. It is designed to supply the instruction and training that cannot be obtained in any of the smaller technical schools, and to give the highest possible training to manufacturers, managers,

Central institution at South Kensington.

foremen, and teachers of technology. This institution will afford an opportunity to many ambitious young artisans to secure the highest technical training who otherwise could not do so, as their circumstances would not permit them to attend any of the polytechnic schools on the Continent.

The City and Guilds of London Institute is thus one of the most potent educational organizations in Europe, and if it continues as it has started out, its achievements in behalf of industry and the industrial classes will be without a parallel in the history of the world. Its magic influence is already felt and acknowledged throughout the length and breadth of the kingdom.

Notice of a few schools sustained by industrial corporations.

Conspicuous among the schools in England sustained by industrial corporations for the benefit of their employes are those of the London and Northwestern Railway Company at Crewe, of Sir William Armstrong & Co. at Elswick, and of Messrs. Mather & Platt, extensive iron manufacturers, at Salford, near Manchester. The object of each of these schools is to enable apprentices to study the sciences allied to their trade. The first two of these schools do not make attendance compulsory, but as the companies sustaining them each employ about ten thousand workmen, the evening classes are attended to their full capacity by voluntary students. At Crewe the number enrolled in the school for the last year exceeded six hundred, which was as many as could be accommodated in the large school building which has been erected and equipped by the London and Northwestern Railway Company. Among these voluntary students were many journeymen who were ambitious to surpass their present educational attainments. Mr. Webb, the efficient General Manager of this company, was the moving spirit in the organization of the school at Crewe, and he continues to be an earnest advocate of technical training for railroad employes.

Attendance at school a condition of employment of apprentices.

Messrs. Mather & Platt require all their apprentices, as a condition of employment, to attend the evening classes in the technical school which the firm has established, and the manager of their works claims that the boys make better headway in acquiring their respective handicrafts by acquiring the related technical knowledge at the same time.

The theoretical instruction in all three of the schools just referred to is very much the same, including mathematics, mechanics, physics, chemistry and engineering. Instruction is also afforded in drawing, machine construction, building construction, and the use and care of tools.

Exhibit H.

Testimony of Mr. Stephen, of Glasgow.

Mr. Alexander Stephen, in a speech before the graduating class of the Allen Glen's Institution, Glasgow, made some pertinent remarks on the subject of technical education, the substance of which was that it is only within the last few years that the importance of teaching science subjects in the schools of the country has come to be realized, and it is satisfactory to observe that the desire for this teaching is increasing from year to year. In past generations facilities for obtaining a knowledge of science subjects were very limited, but now there are institutions and schools where the studies can be carried on which lay the basis and give the taste for science training, so that when the student goes forward to the practical work of daily life, he is the better fitted to take a leading part in the performance of its duties. If the young student can be got to master the first principles of any science to which he may have given his attention in a technical school, he has put himself in the way of being able to prosecute scientific studies successfully in after years, and may even rise to distinction or confer a boon upon society as a consequence of his researches. At the same time the boy is acquiring manual skill he should have an opportunity to continue his elementary education, which will otherwise be of little value to him. The technical school affords this opportunity, and while the boy is taught *to do* he is also taught *to think* accurately on scientific subjects. Science teaching becomes more and more necessary for the development and success of the manufacturing

and other industrial interests of the country. It is a fact that, owing to the greater attention that other countries have given to technical teaching, we have been obliged to have recourse to foreigners to fill positions as designers in our factories. I am informed that this is so in Glasgow, but I think that we are now on the road to overcome this necessity.

In the report of the Royal Commission on technical instruction it is stated, alluding to schools in other countries, that the best examples of higher elementary schools are to be found in France; and in these schools it is said that "the children of artisans and of small shopkeepers have opportunities of obtaining an education which is technical in so far as these studies are directed toward the requirements of commerce, mechanical or manufacturing industry—mathematics, science and drawing constituting the main subjects of instruction. And in nearly all the modern French schools—of which that at Rheims may be taken as the best type—the laboratories for teaching practical chemistry leave nothing to be desired. In these schools the workshop instruction is carried to a much more advanced stage than is possible or desirable in the elementary schools; and there are special departments, replete with models, apparatus and specimens, for teaching the technology of the trades which form the staple industries of the district in which these schools are situated." The Germans are considered to be much ahead of us in technical training, but, now that we have made a start, I trust that we shall soon be ahead of them. Improvements and new discoveries, whether in engineering science or in other mechanical contrivances, are most likely to be made and applied in the light of scientific knowledge.

Exhibit I.

THE MARTIN SCHOOL, LYONS, FRANCE.

[Extracts from Report of British Commissioners.]

This school was founded 50 years ago by a bequest from Major-General Martin, who left Lyons a poor boy, fought against the English under Tippoo Sahib, and entered the service of the East India Company after Seringapatam had fallen. More than 20 years elapsed before the city of Lyons could recover his legacy from the Indian courts, and the school was at length established in 1830 on the remnant saved from the lawyers. The school was intended to give to the poorer classes of Lyons an education which should enable them to improve their position in after-life. M. A. Monmartin thus sets forth the object which the founders of the Martinière had in view in creating this industrial school. "The intention of this school is to instruct the son of the workman, of the artisan, of the small manufacturer or the tradesman of Lyons gratuitously in the sciences and arts applied to industry; to develop in him, on the sole condition that he is intelligent, moral and industrious, those aptitudes which will most surely conduct him to well-being, if not to fortune, and to create new elements of productive force and of future prosperity to the country."

The building, adapted and furnished at a cost of $200,000, contains good class-rooms, each capable of accommodating 80 pupils, a very large drawing-room, in which all the pupils of the different divisions can work at once, workshops, laboratory, museum, library, council-room, director's office, etc., together with several dwelling-houses for the head master and other officials.

The school is presided over by an administrative commission composed of seven members, who are nominated by the Minister of Agriculture and Commerce on the recommendation of the municipality. The appointment is for seven years, and one member retires annually, but is eligible for re-election. The Mayor of Lyons is the *ex-officio* President of the Commission, and the trustee of the fund, under the will of Major-General Martin, is the Vice-President. This committee appoints and dismisses the teachers, selecting them as far as possible from the

old students of the school, but they must have completed their instruction as masters, and have obtained the diplomas of secondary teachers, and, for employment in some branches, of superior teachers.

A principal, a vice-principal, and five superintendents form the administrative staff, and the instruction is carried on under the care of 40 masters and 10 assistant teachers. These latter constitute a division of masters in training, and form an integral part of the organization for teaching, as well as for disciplinary purposes. There are also a registrar and a chemical assistant. * * *

The Professional School of Rheims is a school of a somewhat higher type than the foregoing, and is one of the best of the higher elementary schools which the Commissioners have seen. It was founded on the model of the schools of Mulhouse and Nantes, and differs from the Martinière school by the further development of manual labor in the shops.

The school was established in 1875, in order to impart to the youths of the city of Rheims special practical knowledge of manufactures, and to train them early to satisfy the requirements of her trade and commerce. A municipal commission composed of city councilors, leading manufacturers and tradesmen of the district came to the conclusion that professional education ought properly to be the continuation and the normal development of primary education, and that such a school as this should draw its pupils from those children of the elementary schools who had passed a satisfactory examination.

There is an entrance examination for those who do not possess the leaving certificate of the primary school. The boys enter the school at about the age of thirteen, and the course of study extends over three years. During the first two years all the pupils pass through the same course of theoretical and practical instruction, and the course up to this point serves also as a preparation for the École des Arts et Métiers at Châlons. Very few boys leave at the end of the second year. There is an examination at the end of each year to determine the promotion to the superior division.

In order, moreover, in the brief space of three years to train up these boys so as to be capable of rendering real service on quitting the school, it has been found necessary to enable them to supplement their theoretical studies with practical work analogous to that which they will have to practise in their future professions, and to place at their disposal a complete and well-organized plant for this purpose. Rheims has spent $80,000 to $100,000 on this plant, and has thus placed her schools in the first rank of similar institutions.

The school has quadrupled its number of students since its foundation in 1875, and the number of boarders would be largely increased if sufficient funds were available to defray the cost of another boarding-house. This school received the gold medal at the Exhibition of 1878.

The Professional School of Rouen.

The Professional School of Rouen is another school, much of the same type as the foregoing, but in which more attention is paid to mechanical industries. This school, which was also visited by the Commissioners, was founded in 1853. The director is M. Delarue. The special object of the instruction is to prepare youths to enter the École des Arts et Métiers, but a certain number of the pupils leave the school to enter at once into practical work. The bulk of the pupils are the sons of the small tradespeople of the town; some of them enter with scholarships given by the Government, or by the municipal authorities. There are six exhibitions given by the city of Rouen, twelve by the Department, and four by the State. The education at this school became gratuitous under the law of July, 1881. The school expenses, hitherto paid by the town, have amounted to about £1120 annually. The school course, which combines both theory and practice, extends over three years, and is conducted in very indifferent premises. The boys must be at least twelve years old on admission, and must have the amount of knowledge necessary for the primary-school certificate. Prizes and

medals are given to deserving pupils at the end of each year. Frequent visits are paid to works and factories. There is a chemical laboratory, but the instruction in this subject seems to be inferior to that of the Rhenish school. Instruction in the English language is given to all the pupils. There are about 140 students, half of whom are boarders, and there is a preparatory course for the younger boys. The hours of theoretical study are from 7 in the morning till 6 at night, with three hours of recreation, and in the evening two hours of manual work. They therefore have eight hours of class work and two hours of manual work per diem. The practical instruction consists in working in wood and iron. The handicraft work is carried on in a large room lighted from the top, having desks for drawing down the centre, and working benches against the walls; all the pupils work in this room at the same time. The pupils are put through a graduated series of manipulations; for example, in smiths' work and turning of iron, each pupil has to make in succession every one of the hand-tools mentioned in a list and figured on a table hung up in the workshop. The teachers pay from £24 to £26 per annum. Many of the pupils, after having passed through the school, ultimately obtain situations as foremen; others enter the Government schools of Châlons or Angers. At a recent examination, ten pupils from this school presented themselves for the entrance examination for Châlons, and nine were admitted, being one-eleventh of the total admissions for the year. This fact was quoted to prove that the school is a good one.

The director stated that the object of the education was not to form foremen, but rather to give a general education, calculated to serve as the basis for many trades. He pointed out a school museum containing specimens of various products for object lessons, and stated that similar museums were about to be formed in all primary and higher elementary schools in France. Amongst the specimens, the Commissioners noticed a Prussian soldier's helmet. On being asked why it was placed there, the director stated that it was placed as having the German invasion, and added that it was his custom to point out to his students that France lost her best provinces through the superior education of the invaders, and the helmet served as a constant warning and stimulus to the students.

Enclosure 3.

Westphalia, Germany, is a great centre of iron and coal manufactures. In order to supply their shops with competent managers, foremen, and workmen, the employers have succeeded in establishing a number of schools designed to combine theoretical scientific instruction of the working people with the practice of their callings. The success of these attempts has been very satisfactory. We believe the school at [illegible] is one of the best of these schools. It was the result of private enterprise, and is [illegible] efficiency each year. Instruction is given in modelling, wood-working, smithing, filing, turning, and pattern-making, together with [illegible] both elementary and higher classes. In order to induce lads to [illegible] should not run into the [illegible] to attend a school for two [illegible] served a year or more as workmen in some shop. The preliminary [illegible] is claimed, many students in consequence not apply for admission [illegible] school.

The employers of labour in Westphalia are [illegible] the evening schools, regarding it very much to their interest [illegible] men or lads working at such trade. A subject of [illegible] is [illegible] is fully supported by an [illegible] from [illegible] [illegible] [illegible]

Exhibit K.

J. G. Fitch, an English educator of acknowledged ability, says:

We shall, I hope, ere long, come to the conclusion that the true way to recognize the claims of what are called modern subjects is not by the erection of separate modern departments, but rather by taking a wiser and more philosophical view of the whole range and purpose of school education.

It is not good that the boy who is to be a classical scholar should grow up ignorant of physical laws. Still less is it good that the boy who shows a leaning toward the natural sciences should be debarred from the intellectual culture which literature and language give. * * *

There comes a time, no doubt, when it is clear that we should specialize, but this time does not arrive early; and, until it arrives, it is important that we should secure for every scholar a due and harmonious exercise of the language faculty, of the logical faculty, of the inductive faculty, as well as of the powers of acquisition and memory.

In this connection the following quotation from the catalogue of the Ohio State University is very appropriate:

In nearly every department of life the demand for knowledge and skill is constantly rising. The public is learning to appreciate quality in work. Facility, precision, finish, are acquiring new value. As a consequence the chances of the untrained and the ill-trained are rapidly diminishing, and those who presume to adopt pursuits without the requisite preparation find themselves placed under disadvantages that grow more serious every year.

To meet this increasing demand for a higher order of training, new educational methods are being introduced. That men may be well equipped for their work, it has been found necessary to make their preparation for it a part of their education. The young man who is to become a civil engineer should receive practical training as an engineer. If he is to become a chemist, he should receive practical training in the laboratory. Many look no farther than this; but technical training should be based on scientific training. The civil engineer should not be content with knowing how to handle his instruments, but he should be a mathematician of extensive attainments and ready skill, and should be master of the principles of physics and mechanics. The chemist should not rest in a knowledge of processes and manipulations, but he should be well versed in chemical philosophy. In medicine, in law, in teaching, on the farm and in the shop, in every occupation which involves human interests and requires the application of human intelligence, empiricism should be supplanted by scientific knowledge.

There is no employment in which intelligence is not worth more than mere manual dexterity. A man of scientific knowledge and training, other things being equal, will even shoe a horse better than one who lacks them. The educated hand is a hundred times better than a hand without education. But the educated hand is made a hundred times better by being placed under the direction of the educated brain.

Exhibit L.

Facilities now afforded in U. S. for technical training.

NOTE.—This exhibit contains a brief account of the nature, organization, and work of most of the leading industrial schools of the United States, including the industrial departments of some of the great universities. It aims to show to what extent facilities for technical education are now afforded in our country. The information has been obtained from various sources. In some instances extracts have been made from reports without giving credit.

THE ROSE POLYTECHNIC INSTITUTE.

The Rose Polytechnic Institute at Terre Haute, Indiana, is one of the best endowed and most promising of all the schools supported by private endowment, and providing for higher technical training on an extensive scale. Mr. Chauncey Rose, its liberal benefactor, placed over half a million dollars in the hands of trustees for the endowment of an industrial educational institution to be located at Terre Haute. He instructed the trustees to obtain all the information they could relating to European and American schools, and then to incorporate the best features of these into the school they were about to establish. The institution has now been in operation for about ten years. It has an annual income of $30,000, and a reserve fund of $75,000. It is an institution of great promise, and will undoubtedly result in great good to both laborers and employers within reach of its beneficence. The trustees of this school have lately given evidence of far-seeing wisdom by the election of Dr. T. C. Mendenhall to the presidency, and in giving him large liberty in shaping the policy and managing the details of the institution. Although they have to pay Dr. Mendenhall a salary of $5,000 a year, yet his attainments in scientific and mechanical knowledge are so great, his experience in teaching and in original scientific research has been so extensive and successful, and his characteristic energy and executive ability are so desirable in a school of this kind, that his services as president will be well worth that amount. With its liberal endowment and able management, the country at large has a right to expect great things from this young institution.

THE COOPER INSTITUTE.

The Cooper Institute of New York City, established and supported by the munificent bequest of the late philanthropic Peter Cooper, is one of the most practical technical schools in America. It affords free technical instruction to both sexes, and is especially designed to meet the wants of the working-classes by affording them practical instruction in science and art. The spirit that pervades the management of the institution is such as to be in keeping with the object for which the school was founded. That the working-people appreciate the opportunities of improvement thus afforded them is proved by the large number of students who annually attend its classes. In 1882 the number of pupils was about 4000, and more than half of these attended the evening classes after having been engaged in the discharge of other duties during the day.

There have been more than 3000 students in the evening science and art classes at one time. The science teaching is done by able instructors, and is designed to be especially useful to artisans by relating to the various occupations in which they are engaged during the day. The labors of the students are of a practical character, and the finished products that are possessed of merit are disposed of to various business firms of the city, the proceeds of the sales going to the students who turn out the products. In one year the students earned $40,000 for work executed in the school at the same time they were receiving instruction in science and art.

The library and reading-room are a prominent feature of this institution, and the average daily attendance at these places is 1500 persons.

Mechanics' Institute, Cincinnati.

At Cincinnati, Ohio, there is a Mechanics' Institute, established in 1829, for the purpose of furnishing educational aid to mechanics, manufacturers and artisans. Efforts are now being made to organize in connection with it a complete school of technology.

Cleveland and Toledo.

Both Cleveland and Toledo have industrial schools that have been quite liberally endowed, the one to the extent of $125,000, and the other $100,000.

Pardee Scientific School.

The Pardee Scientific Department of Lafayette College, Easton, Pa., has an endowment of $200,000, and buildings and equipment that cost $300,000, all the gift of one man. This endowment was made with special reference to the promotion of scientific education. In some departments of science, such as metallurgy and engineering, instruction is supplemented by practice.

Miller Manual Labor School.

The Miller Manual Labor School, Batesville, Albemarle County, Va., has only lately been organized. It is richly endowed, to the extent of one million dollars, by the will of the late Samuel Miller, of Batesville. It is designed to afford poor children an opportunity to obtain a practical education. Manual labor is required of all the pupils in the several departments of industry. Already instruction is given in carpentry, telegraphy, farming and gardening.

Working Man's School.

The Working Man's School, another institution of New York City, is designed to meet the wants in a practical way of the laboring classes. The school is designed to educate children for industrial pursuits in such a way that they may become thoroughly intelligent and dexterous working men and women in some particular department of industry. The projectors of the school are endeavoring to carry out what they call the *creative method* in school training. The plan is to continue the system of kindergarten training, only adapting it to the various ages of the pupils. The education of the brain is to result from the training of the hand and the eye. Pupils are to learn by doing. The workshop and the school-room here become practically the same thing.

This school, which has now been in successful operation for a period of about seven years, is supported by the "Society of Ethical Culture."

Industrial Training in Cornell University.

The industrial departments of Cornell University, Ithaca, New York, are perhaps the most practical and efficient of any that are maintained in the higher institutions of our country. Although designed for only advanced students, the courses of study are so judiciously arranged, and the conditions of admission so liberal, that the instruction is really accessible to a large number of promising students. There are courses in agriculture, mechanic arts, civil engineering, mining engineering, applied mathematics, electricity and electrical engineering, free-hand drawing, chemistry, and physics. The farm contains 120 acres, and is used for experimental purposes. Students of agriculture spend several hours each week in the performance of manual labor on the farm, thus having opportunity of reducing their theory to immediate practice.

In connection with the department of Mechanic Arts there are a brass foundry, a blacksmith shop, and various kinds of machines and tools, and these are frequently used by both teachers and students. No other institution of so high standing is doing so much in the way of advancing the industries and encouraging the development of our great resources of wealth as is being done by the industrial departments of Cornell University. About one-fourth of all the students in the institution are receiving technical instruction.

School of Mines, Columbia College.

The School of Mines of Columbia College affords excellent practical instruction of an advanced character to students of mining, engineering, architecture, and certain kinds of machine construction. It is one of the very best schools in America for young men of means and talent who desire to fit themselves for the management or other prominent positions in the great industries. Students in mechanical engineering are required to devote a certain amount of time to shop practice, in which they are taught the use and care of tools, besides acquiring some skill in practical work. "The professors take out companies of students to mines, smelting works, iron works, and machine shops, to demonstrate their theoretical teaching by practice on a commercial basis. Students are encouraged to seek *actual employment* in various works during vacations, and many do so."

The Massachusetts Institute of Technology.

The Massachusetts Institute of Technology has deservedly attained a world-wide reputation. It was organized in the year 1861, under State charter, as an "institution devoted to the practical arts and sciences, having the triple organization of the society of arts, a museum or conservatory of arts, and a school of industrial science and art." The object of the institution was the advancement, development and practical application of science in connection with arts, agriculture, manufactures and commerce.

Unlike the industrial departments of Cornell University, the Massachusetts Institute of Technology has courses of instruction adapted to intermediate as well as to advanced students. Boys may go directly from the public schools into this institution and take a course of technical training of two or more years that will enable them to enter at once upon an industrial career with prospects of success.

The equipment of the class-rooms, laboratories, workshops, museums and libraries in this school is better for the kind of instruction attempted than can be found in any other technical institution in our country.

That the school is eminently successful is evident from the large number of promising students who seek admission to the classes, and from the great demand that always exists among employers for the services of those who have

received the training which the school affords. Graduates of this institution are to be found occupying positions of prominence in almost every part of the United States.

Worcester County Free Institute of Industrial Science, Mass.

This technical school was chartered by the Massachusetts Legislature in 1865 and opened in 1868. In its general plan it follows the polytechnic schools of Europe, but gives special prominence to practical work.

Candidates for admission must have attained the age of 16, and pass an entrance examination in history of the United States, geography, grammar, arithmetic, algebra and French. Candidates can enter advanced classes by passing the necessary qualifying examinations.

Residents of Worcester County are educated gratuitously, and there are also 20 free studentships open to persons resident in other parts of the State of Massachusetts. Other students pay $150 annually.

The instruction is based on mathematics, living languages, the physical sciences and drawing, together with a practical familiarity with some branch of applied science, and serves for the training of mechanics, civil engineers, chemists and designers. The courses extend over three years of 42 weeks each, except the mechanical engineering course, which is one of three and a half years. After half a year's attendance at the school each student must decide upon the special branch of study which he will take up—viz.: chemistry, civil engineering, physics, or drawing. The mechanical engineering students commence work in the shop immediately on entering the school.

Certain studies are common to all departments, the school aiming at giving a complete general education.

The Institute grants degrees to students who pass with distinction through its courses.

Over 90 per cent. of its graduates have easily obtained honorable and lucrative employment.

The most interesting feature of this school is the Washburn machine shop, in which the mechanical students spend two days per week of five hours each under the tuition of skilled workmen. This shop is a manufacturing establishment, and so the students work under manufacturing conditions, and with the best and most recent tools and machinery. In the wood-room the students go through a course of bench work, wood turning, and machine sawing and planing; and in the iron-room through a complete course of vise and lathe work, milling, planing, screw cutting and tool making; finally receiving instruction in designing machinery and undertaking the construction of complete machines from their own drawings. It is expected that at the end of his course the student will have a mechanical aptitude equal to that of any ordinary apprentice of the same years' standing, whilst he will have received at the same time a sound scientific education.

This school is said to have a yearly income of about $25,000, while the average excess of expenditure over income is about $3000.

Washington University Manual Training School, St. Louis, Mo.

In addition to the previously existing collegiate and professional departments of the University, a Manual Training School was established in 1879. The land, building and equipment have cost in all nearly $65,000, the money having been contributed by private individuals.

Candidates for admission must be at least fourteen years of age, and must pass an examination in arithmetic, geography and English composition. The course of instruction extends through three years, and embraces arithmetic, algebra, geometry, plane trigonometry, book-keeping, physics, mechanics, mensuration, mechanical drawing, physical geography, English language and literature,

practical ethics, political economy, music, and shop work. The shop work occupies two hours each day, and includes carpentry, wood turning, pattern making, forging and machine work in iron.

Besides the students of this school, students in other departments of the University are allowed and advised to take shop work. At present there are 170 in all who have shop exercises.

In arranging the work, regard is paid to its educational, and not to its commercial value; and no choice is allowed to the student in work or in the studies, as the object is not to teach any particular trade, but to lay a good general broad foundation for subsequent special pursuits.

Girard College, Philadelphia.

This institution possesses property which has increased in value rapidly and very largely, and the college now maintains and educates over 800 orphan boys. Shop work in iron was introduced in April, 1882. The manual instruction is proving very acceptable and beneficial. It finds an unquestionably appropriate place here, since the college does not aim at the highest standard of instruction in literature and science, but seeks rather to prepare those under its tutelage for making their own living by industrial pursuits.

Stevens Institute.

The Stevens Institute of Technology was established in 1872. The aim of the school is to afford a thorough technical training in mechanical engineering, by combining theory and practice in the instruction. Great stress is laid upon mechanical drawing, original designing and mechanical construction. The school is well supplied with workshops furnished with all kinds of machinery pertaining to the subjects that are taught. The shop instruction includes actual practice in moulding, casting, turning, planing, drilling and fitting. No attempt is made at teaching trades, but students are so thoroughly instructed in the use of tools and the principles involved in engineering that they may very readily learn to be efficient mechanics and managers in the works where they obtain employment. This school furnishes another instance of the practicability and desirability of combining theoretical and practical instruction.

Rensselaer Polytechnic Institute.

This is a school of theoretical and practical science, at Troy, New York. As a school of engineering it holds deservedly high rank. Its graduates have taken a prominent part in some of the greatest engineering feats of this country. In railway construction, waterworks, bridge building, and in large industrial establishments, they have demonstrated the great value of practical scientific knowledge and training. The engineer of the Brooklyn Bridge was educated at this school.

Mechanical Course, Purdue University, Lafayette, Indiana.

This University provides for a technical and scientific course. It has a well-equipped chemical laboratory, a large physical laboratory, a choice museum of natural history, a large geological cabinet, and other appliances for scientific training.

The first two years of the mechanical course afford technical training for machinists and other mechanics, and are a good preparation for a course in civil and mechanical engineering. The course provides for two years of shop practice (two hours daily), and one year's instruction in mechanical drawing, besides instruction in mathematics, science and English.

SCHOOL OF AGRICULTURE AND MECHANIC ARTS, UNIVERSITY OF CALIFORNIA.

This is one of the most important schools of practical science in America. Its students enjoy the benefits of a splendid library of 20,000 volumes, as also of extensive and well-equipped laboratories and museums. Engineering, mining, and agriculture are the principal technical subjects that are taught.

Exhibit M.

Extracts from Mr. Mather's report.

Mr. Mather, in concluding his report to the British Commissioners on Technical Education in the United States, says:

Technical and science schools in America.

It will be seen, from the foregoing description of the technical and science schools, that there exist in America a certain number of *high-class* institutions for technical and scientific training in mining, civil and mechanical engineering. I am of opinion that in these branches, judging from my own observation, there is nothing better of the kind, though such institutions are more numerous at present in Europe. The advantage of the training in the best of them is its *practicalness*. The students feel that careers are open to them if only they have acquired the art of applying their knowledge; hence their ambition is excited, and every one of them appears to be working for a definite purpose. There is nothing pretentious about these students. Some of them are poor, but they must have shown marked ability in order to get the advantages of the free, or partially free, instruction. Thus a limited number of clever sons of workingmen have the road opened up for a thorough scientific training, if they can afford to give the time.

It is much to be deplored that in the majority of institutions in America where science is taught in the abstract there are no departments arranged for such technical training as exists in some I have described.

These schools cannot supply the demand for industrial training.

The demands made upon those which give technical instruction are greater than they can satisfy. This accounts for the high fees charged, and also for the fact that the advantages of such technical schools are in the main confined to the sons of wealthy manufacturers or professional men.

The lower-grade science schools connected with the numerous colleges in every State, and semi-private institutions, as described under the head of "Universities and Colleges," are rendering considerable service in the direction of science-teaching to a less wealthy class in the country. Their courses of study, however, require remodeling. To each one of them ought to be attached departments similar to those at Cornell University and Washington University, with ample provision for the admission of free students.

There appears to be excellent provision made in America in such colleges as the Johns Hopkins of Baltimore, and Columbia College of New York, and the like, for the training of able professors and for the continued development of original research in all the sciences. The "Sheffield School of Science," connected with Yale, and the "Lawrence Science School" of Harvard University, may also be classed amongst institutes aiming at the higher education in scientific knowledge.

There are also sufficient schools and colleges, aided by the taxes of the people, to supply, if properly used, ample opportunities for the whole industrial population—proprietors, foremen and workpeople—to acquire, in early life, a sound scientific education by means of a technical course of studies. The only change required is in the curricula of such institutions, and the broadening of their systems to the wants of the age.

There can be no doubt that America owes much already to the schools which exist for technical education, though not actually helping the artisan class. Many hundreds of young men have been furnished from these sources for the superintendence of railway works, mining operations, machine shops and the textile industries, besides chemical work, glass manufactories, building operations, agriculture, etc. I have met in almost all the manufactories I have visited—from mining, iron and steel manufacturing, through all the mechanic arts, up to watchmaking and sewing-machine manufacturing—evidences of the influence of the technical schools.

Much has been done by these few schools.

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From many conversations with owners of industrial establishments, I find the prevailing idea to be that everything appertaining to education is to be done in the public school. Moreover, the general aptitude, inventiveness and industry of the American young men, animated always by ambition, and backed by the ability to read, write and reckon well, have furnished employers with intelligent mechanics after a comparatively short service in the workshops. All Americans have, more or less, the mechanical faculty. It is the characteristic of the race. The problems involved in settling the country have been more mechanical than political. In early times almost all men and all women were engaged in manual work and in exercising their wits to avail themselves of the forces of Nature. To this natural bias the public-school education gave the means for higher development. The demand for mechanical contrivances to save labor held out the promise of great reward, and the protection of cheap patents gave confidence and security. Thus the workingmen of America have been educated and brought up under conditions different from those prevailing in Europe.

Disposition to depend on public schools.

It is impossible to traverse this vast continent without witnessing the evidences of originality of application founded on scientific principles, and of a development due to education in the mechanical arts. In the railroad system, from the locomotive to the baggage-car, there are original design and marked ingenuity in every contrivance; in bridge-building, great daring and ready devices for temporary, yet safe, structures; in the navigation of rivers there are boats which differ from all European systems. The shallow rivers, like the Mississippi in summer, are navigated for a thousand miles by steamers drawing less than twelve inches of water. The Ohio conveys from Pittsburgh thousands of tons of material by boats drawing nine inches of water. Towns like Chicago, Denver and San Francisco are built under difficulties which require an entire departure from all old methods of applying science. The produce of the great agricultural regions suggested new modes of tilling, sowing and reaping, and in agricultural machinery the Americans showed how quickly and directly science could deal with vast products which would rot on the field but for mechanical skill to preserve them. The same aptitude that dealt with the overwhelming abundance of the West has turned to account the sterility of the East, where, in Maine, New Hampshire and Vermont, the mechanical skill of the farmer in devising economical methods has contributed as much to his support as his knowledge of cattle and crops.

Evidences of American ingenuity.

It is, of course, in the more recent structures and modern mechanical appliances that the evidence of scientific truths and methods is observable. The rough-and-ready contrivances of early railroad development indicate originality and "mother wit"; but in the waste of material and crudeness of design may be noticed the absence of technical or scientific training on the part of those who conducted extensive engineering or mechanical operations in those days. The gradual diffusion of science is very marked in the rapid reconstruction, during recent years, of the great railroads of the past and in the new main lines. Also, in railway plant generally, the old is being replaced by the new, and the latter exhibits high theoretical knowledge combined with practical ingenuity.

Application of scientific principles observable only in more recent structures.

Americans owe much to Europe.

The Americans undoubtedly owe to European engineers the rapid advance they have been able to make in their public works. The conservation of water-power for the use of the mills at Lowell and Lawrence, in Massachusetts, is due to the eminent hydraulic engineer, Mr. Frances, an Englishman, who practised for forty years in America. The water rights of a district are held in trust for the whole community by a board or corporation elected for the purpose. The power is distributed according to the share which may be purchased or rented by the users, but regard is had to the rights of all, and its utilization requires great skill and knowledge to prevent loss of power. Mr. Frances has had charge of this important work for many years, and is deservedly esteemed as the highest authority on hydraulic engineering in America. Although a lucrative field was, in the early days, open to European engineers and machinists having a thorough scientific knowledge of their profession, yet it is evident that they found apt scholars, who, as they acquired some theoretical science, launched out into new paths, untrammeled by the traditions of the older countries.

Even the science of foreigners, when applied here, takes different methods. The Englishman and German become bold and self-confident to a degree only manifested by rare men in Europe. The everlasting thirst for *something new* excites, stimulates and drives men to venture into untrodden paths in applying their knowledge. In the manufacture of machine tools and every kind of mechanism where the interchangeability of parts would be an advantage, the design and construction have been made subservient to this law. It may be truly said that the Americans have carried to its utmost limits one of the greatest improvements in modern times in mechanical construction—namely, in their extensive introduction of the principle of the interchangeability of parts in machinery. Watches, sewing-machines, tools, agricultural implements, printing-presses, firearms, etc., are made with an accuracy so fine as to approach the theoretical, and yet more cheaply than the rudest and most imperfect work. All these evidences of scientific skill speak well for the methods of education in the recent past, so far as it goes; but other influences, such as "necessity, the mother of invention," and the presence in America of foreign experts, will account for much of the rapid growth in the mechanic arts.

Technical science schools essential to future development.

The future development will depend upon a population not compelled to dare and endure and experimentalize for "very life." In the past the waste of material has been excessive. To make the best use of a given quantity of material requires a sound knowledge of its properties and of its disposal in the arts and manufactures by scientific methods. In this direction the technical and science schools already instituted have accomplished much in providing foremen and managers, chemists, miners, and intelligent employers in the engineering and manufacturing industries. Some extensions of these institutions are now being promoted. One significant indication of progress in this direction was afforded me during my travels. I attended a convention of about a thousand teachers, professors and principals of schools and colleges at Saratoga, and another similar gathering in the White Mountains. The discussion of technical and industrial training was the chief feature of the conventions. I was much impressed by the high qualities of culture and character which distinguished this truly "Grand Army of the Republic" in its 300,000 teachers, as represented at these meetings. If this force should be directed by a change of tactics, so to speak, in the schools to scientific and technical instruction, and to less concentration upon purely literary subjects, there can be no doubt that America will solve the industrial-education question more rapidly than any other country and utilize it in the further development of her inexhaustible resources.

It must not be supposed that Nature has bestowed her gifts over this continent in such wise that they can be enjoyed without much skill and labor in the gathering of them. No country offers more difficult problems to the engineer, the agriculturist and the manufacturer. A climate of extremes; a scarcity of water in the West; the difficulties of cheap transport and distribution, all require the highest qualities of self-reliance and endurance, with scientific knowledge, in the progress of the future. * * * * * * * * *

This splendidly endowed institution (the Johns Hopkins University) is taking rank amongst the highest universities of America. The regular curriculum of a university course is followed here. The University was opened seven years ago. The bequest of Johns Hopkins amounted to £700,000. The interest was allowed to accumulate until a sufficient sum had accrued to enable the trustees to erect handsome and commodious blocks of buildings on land bequeathed by the founder. Johns Hopkins University.

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This University is devoted chiefly to the highest branches of education in mathematics, physics and medical science. It is conducted on the lines of Owens College of Manchester, with a bias more specially to original research and scientific discoveries, both in chemistry and physics, than to preparing for industrial pursuits. There are no night classes, so that all the teaching is confined to those who can afford to pass through all the courses in the day classes. Dr. Gilman informed me they had some instances of workingmen having, at great self-sacrifice, come to them to obtain a thorough scientific education. The total fees for all subjects amount to £16 per annum.

Dr. Gilman, in answer to my inquiries, stated that some of their professors had delivered popular lectures to the working classes, but he did not regard these as having much influence on working-people generally, in relation to their occupations. He would gladly use the institution as a means of technical training, but did not yet know of a scheme that was practicable there.

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One might expect from so richly endowed an institution a more direct relation to scientific industry than appears now to be the case. With an income of £30,000 a year without fees, it would appear possible for a large amount of work to be done among the people of the city without in any degree diminishing the highest instruction in the advanced stages of literary and scientific knowledge.

Baltimore does not possess any large or distinctive manufactures. The trade is chiefly that of timber and grain export, with workshops for railway purposes. The Baltimore and Ohio Railway shops employ 3000 artisans, for whom there is little provision for science instruction beyond the drawing classes I have described.

I found much interest displayed in the question by the authorities of the railway to whom I was introduced, and they expressed their desire and intention to provide suitable science schools for their workpeople.

Exhibit N.

Perhaps no views are better worthy careful consideration than those of Dr. Philbrick, of whom the Commissioner of Education says:

It is acknowledged the world over that to him is largely due the excellence of the Boston schools. A thorough man of affairs, accurate and broad in his scholarship, in the fullest sympathy with American institutions and ideas, he not only watched and guided the Boston schools that grew under his hands for twenty years, but, by travels and studies in different parts of this country, and two visits to Europe—one of which included official duties in connection with the Exhibition at Vienna, and the other the special organization, care and management of the American Exhibition of Education in Paris in 1878—he had the vastest opportunities for extensive personal observation elsewhere in school matters, and for philosophical deductions therefrom. In his retirement, and with his accumulation of literature, of observation and of experience around him, he has consented at my request to prepare the following report on education Ex-Commissioner Eaton's opinion of Dr. Philbrick.

in cities. * * * Every one will see that, to secure the fullest benefit to the millions interested in the wise administration of education in our cities, and the millions yet unborn to be affected by it, the writer of this report (is) possessed of rare qualifications for the undertaking. * * * I may add that I know of no more valuable study of city systems of public instruction than that presented by him.

Extracts from Dr. Philbrick's Report on City School Systems of the United States.

Industrial Education.

What is meant by industrial education.

It may be well, in the first place, to define what is meant here by the term industrial education, which is used rather loosely in the current discussions on the subject. Some writers use it in the same sense as technical education; better usage makes a distinction, however. J. Scott Russell, in his masterly book, "Systematic Technical Education for the English People," gives to technical education a broader meaning than that which belongs to industrial education, making it include all that education which teaches the knowledge required to fit men for some special mode of gaining their livelihood, and thus embracing the instruction of the highest professional schools, as well as that given in schools designed to form the handicraftsman of the humblest degree. Non-technical or general education, on the other hand, is that which has for its object to train and send into the world able men of matured intelligence and ripened powers, good for all the vocations of life and prepared to enter upon its duties with sound bodies, developed ability, and formed character; but it is not designed to communicate that special knowledge or to develop that special skill which fits a man for the particular calling or profession which he will have to choose as his life-work. This general education is the necessary basis and accompaniment of efficient technical education. Large education, broad development, a generous general training, are the best possible foundations of useful after-life, but they are only the foundations of the knowledge and skill requisite for professions and trades. This knowledge and skill it is the function of technical education to impart; it gives that special training which renders the educated man both self-supporting and directly useful to society. I willingly adopt the signification given to technical education by so eminent an authority, although my choice would be to call all that education which is not general, professional, after the nomenclature of the French pedagogy.

Two divisions of technical education.

Technical education in this comprehensive sense is composed of two tolerably well-defined divisions, the one being that which is concerned with the social professions and those relating to the fine arts, while all other occupations and pursuits requiring the application of science, art and manual skill are included in the other division. This province of technical education is what we mean by industrial education, which has for its scope to impart the knowledge and skill requisite for success in the three great departments of practical life—namely, agriculture, manufactures, and commerce; or, in other words, in producing the raw material from the ocean, the mines, the forest and the field, in converting these materials into useful forms, and in their transportation and exchange.

In its widest sense industrial education comprises not only all that a man does for himself, but also what is done for him by others to bring him nearer to perfection as a worker in any branch of industry.

In a more limited sense industrial education is that which is designed to impart the knowledge and skill requisite as a preparation for successful work in that department of practical activity which is concerned in changing the raw material into useful forms, or the manufacturing industry.

In former times knowledge and skill in industrial pursuits were almost exclusively acquired by means of apprenticeship. This held true not only of the mechanical trades, but of the liberal professions as well.

That state of things has passed away. An auxiliary instrumentality has been created by the demands to advance civilization; that instrumentality is the technical school, in its elementary, secondary and superior grades, and in its ever-increasing diversity of aim and purpose. Industries made but comparatively slow progress while they were carried on by persons whose instruction was limited to apprenticeship. Gradually, and in more recent times, the idea has made its way that the progress of an industry depends especially upon the degree of instruction of those who exercise it. This led to the establishment of industrial schools. The competition of industries is rapidly multiplying these schools, and from present indications these schools are destined to a development far beyond that as yet attained in the most advanced community. Industrial education is of two kinds: first, that which consists in imparting a theoretical knowledge and the applications of science and the principles and rules of the useful arts, such as may be given in the class-room and laboratory by the teacher and professor; second, that which consists in imparting the manual skill and the applications of science and the rules of the arts necessary to form the handicraftsman, of whatever grade. This is the education of the shop. The school for imparting this branch of industrial education is therefore primarily and essentially a workshop, supplemented to some extent with the theoretical training of the schoolroom and the manipulations of the laboratory. The considerations relating to industrial education here submitted must be limited to that portion of it which is imparted in schools, and, moreover, such schools as properly come within the scope of city school systems.

Theoretical knowledge and education of the shop.

No school question is at present more agitated among us than that of making manual training a branch of instruction in the common school. Some extremists maintain that trades should be taught in the schools in connection with the common branches now required, so that when the scholar graduates he will be prepared to earn his living as an artisan on leaving school. Others, more moderate in their views, would not undertake to teach trades in school, aiming only to exercise the pupils in the use of the principal tools in working wood and iron. So far the different theories on the subject have been put into practical application only to a very limited extent. The two important practical questions in this connection which claim our attention are, first, what has been already accomplished in the direction of industrial education in our city school systems? second, what does experience indicate as desirable improvements to be undertaken in the department of industrial education? * * *

Handicraft as a Branch of Public Instruction.

There are two modes of giving instruction in handicraft in schools: First, by annexing the workshop to the school for general education, whether elementary or higher. This mode is sometimes called the putting of the workshop into the school. Second, by establishing technical schools for apprentices, consisting primarily of the requisite shops, with appliances for giving the theoretical instruction applicable to the trade taught. This mode has been denominated the putting of the school into the workshop. * * *

The workshop in the school and the school in the workshop.

Superintendent Marvel, of Gloucester, Mass., in referring in his report to an experiment tried in the schools of that city, remarks as to its results as follows:

"This attempt to combine intellectual and manual training will tend to dignify manual labor in the opinion of many young people just at that critical period when so many are now wasting opportunities for practical education in a vain endeavor to accomplish purely intellectual work for which they are totally unfitted. Recognition in the public schools that mechanical occupations are equally as important as the professions or as mercantile pursuits, and that the scheme of public instruction is broad enough to afford an education adapted to the needs of all classes of citizens, cannot fail to have a marked effect upon the succeeding generation. Boys and girls will deem it no less honorable to be found in the fields and workshops than in stores and offices, so long as they are engaged in legitimate and honorable occupations."

Exhibit O.

As supplementary to their investigations into the influence exercised by technical and other schools on the efficiency of foremen and other employes engaged in the principal industries of England, the Royal Commissioners secured the views in writing of a large number of manufacturers and other employers of labor upon the following points:

1. As to the influence on industries in which these employers were engaged of the science and art classes, and other sources of technical and general instruction that are available to apprentices, workmen and foremen; and 2. As to any means whereby such instruction may be rendered more useful.

Attention is invited to the appended extracts from a few of their replies, which, summarized, were to the effect that the schools are exerting a decidedly beneficial influence upon both the industries and the laborers through whom they are developed. These statements, coming as they do from men who are immediately engaged in the industries which the schools are designed to improve, are significant in their testimony concerning the direct and indirect value of technical education. They are from men who are likely to take a practical view of matters, and who are accustomed to decide upon the merits of things solely with reference to their economic results.

Notice should here be taken of the fact that English technical schools are not nearly so efficient as those on the Continent. Most of them have not been long in operation. Many are poorly equipped, and others badly managed. The best schools are the ones that have only lately been established, and consequently they have not yet had time to make their influence very extensively felt in the factories and shops. Besides this, it is only very lately that employers have taken interest enough in the schools to encourage and require their employes to attend the classes. Yet, notwithstanding all these adverse considerations, it will be seen that the opinions expressed in the letters referred to are decidedly in favor of the maintenance of science and training schools in industrial communities, and it is safe to predict that this sentiment will increase when the schools are made more efficient and have had a longer time in which to make results.

Only such parts of a portion of the answers are given here as relate to the influence of the schools upon industry.

FROM MESSRS. KELSON & CO., IRON-WORKERS, LEEDS.

Night schools attract young men.

"There is in our works a growing tendency, on the part of the hands employed, to greater intelligence and earnestness in the execution of the work allotted to the respective departments. The night classes at the Leeds Mechanics' Institute have long been an attraction to many of our young men."

FROM HORROCKSES, MILLER & CO., COTTON MANUFACTURERS, LONDON.

"Many occupying leading positions in our employ owe their general competency to such advantages."

FROM JAMES DIXON & SON, METAL-WORKERS, LONDON.

Advantageous to foremen and others.

"We are of the opinion that these schools have had from the beginning a very beneficial effect upon the foremen and workmen of our district, and that the amount of benefit that is accruing to the trade is increasing year by year. As the men who were old scholars are more intelligent and artistic workmen, their influence has a corresponding effect upon their apprentices, and induces them to send them to the schools."

FROM SIR WILLIAM ARMSTRONG, SHIPBUILDER AND MANUFACTURER OF GUNS, NEWCASTLE-UPON-TYNE.

"The technical instruction given in the institution attached to these works has undoubtedly a beneficial influence on the industries in the locality. Our experience of the classes is that they not only develop thought and intelligence, but they also tend to foster studious and steady habits and to raise the tone of the students." Technical schools develop thought and intelligence and foster studious habits.

FROM JAMES HUMPHRIES & SON, CARPET MANUFACTURERS, KIDDERMINSTER.

"We have an excellent school of art, which has proved of great use in assisting to raise efficient draughtsmen and designers for our principal industry in this town—namely, the manufacture of carpets. Whereas, some years back, we were compelled to go to France and Germany for designs, we are now practically independent of other countries, as far as carpet-designing is concerned." Art training raises up draughtsmen and designers.

FROM THOMAS TUPLING & CO., CARPET MANUFACTURERS, LONDON.

"The influence of art classes in raising the style of design and workmanship cannot be too fully appreciated and encouraged."

FROM MESSRS. HUNT & RUSKELL, METAL-WORKERS, LONDON.

"The influence of the science and art classes on our artisans is of the highest value, for they develop ideas of conception and taste that would otherwise lie dormant, and the training afforded by these classes raises the workman above the mere mechanical drudgery of his employment. We believe the same influence awakens a desire to cultivate refinement in the execution of his work, a sentiment that might have been lost but for the exterior educational aid afforded by the classes." Schools raise workmen above mere mechanical drudgery.

FROM MESSRS. CROSSES & WENKWORTH, COTTON MANUFACTURERS, BOLTON.

"We regard the science and art classes carried on in Bolton as having conferred incalculable benefits on the industries of the town and district, and we look to them principally for the improvement in general knowledge of our workmen, and to fit them to become foremen." Benefit to the town and district.

FROM J. K. GIRDWOOD, LINEN MANUFACTURER, BELFAST.

"At present there are only the classes held in the Workingmen's Institute and the School of Design available for workmen and foremen, both of which classes have been of great assistance to many of our employes attending them."

FROM EDWARD STEEGMAN & CO., LACE MANUFACTURERS, NOTTINGHAM.

"The influence of the classes is decidedly good, and the science classes are very well attended." Influence decidedly good.

Exhibit P.

This and the preceding exhibit are designed to show the importance that employers attach to technical schools, and the comparative value of educated and uneducated labor.

In answer to inquiries concerning the value of educated labor lately proposed by General Eaton, United States Commissioner of Education, some very suggestive letters were received from employers and others interested in industrial pursuits.

General Samuel Thomas, of Columbus, Ohio, who employed 500 laborers in his extensive iron-works, answered the inquiries referred to as follows:

Educated labor needs less supervision and results in better products.

Men who have education require less supervision. The saving to employers in this way alone amounts to fully 10 per cent. Employers suffer constantly from ignorant employes doing their work poorly, and doing less of it for the same wages. This amounts to fully 10 per cent. more.

A knowledge of chemistry, geology, working of mines, and, in fact, all the physical sciences, would add to the efficiency of all laborers in our employ. Not that I expect all to advance to the higher departments; but, with their common-school education, they should have some knowledge of the sciences I have named. In many ways men with such advantages could produce more in twenty-four hours with no more labor, and, as a consequence, command higher wages.

Labor-saving improvements the result of education.

All the labor-saving improvements are the result of education awakening the mind to struggle for something to save much and throw the labor upon machines of iron and wood, so far as I have observed in our works. The ignorant man imitates some one else, and, if he is watched, continues to do so day by day, and by these means earns his living; but he is a great tax upon capital. We pay 20 per cent. more wages to a skilled laborer in our employ, with an education that makes him worth it to us, than to an uneducated man struggling to fill the same kind of place, but not worth so much.

I would not employ as a superintendent or foreman a man who could not read and write; all other things being equal, I consider a man better and better qualified for supervision of labor as his education increases.

The man with some education or some mental training shows his superiority over the ignorant man at home, and by his social and moral influence, to a greater degree than in the shop or at labor. He is more moral, less disposed to be vicious, more industrious. As a class they live in better houses, have better surroundings, and seem to be happier men in every way.

Mr. S. P. Cummings, of Boston, Mass., Secretary of the Massachusetts Grand Lodge of the Order of St. Crispin, Chairman of the Executive Committee of the International Labor Union and of the State labor party, wrote as follows to General Eaton:

The value of skilled labor over unskilled, both as to productiveness and compensation, is fully 20 per cent.

Scientific knowledge would increase production.

A knowledge of the scientific subjects would increase production and wages fully 20 per cent. over the present, inasmuch as the effect would be to stimulate laborers to produce better articles, and consequently increase their means of enjoyment.

* * * * * * * * * *

I have a large personal acquaintance among manufacturers, and they generally agree that their foremen's money value depends largely on the education they possess.

Inventive culture, as a rule, increases the self-respect and improves vastly the social habits of workingmen.

Educated workingmen live in better houses, have better surroundings, and are in all respects superior to those whose education is limited and defective. They are less idle and dissipated than the untaught classes. As regards economy, morality, and social influence, educated laborers are pre-eminent among their fellows. I may add one general observation—that while I was foreman of a shoe factory employing forty hands, I always got better work, had less trouble, and, as a general rule, paid better wages to the more intelligent workmen. The more ignorant hands were continually giving me trouble, either by slighting their work or by failing to appear in a fit condition to work after pay-day. They were, many of them, coarse and vulgar, drank liquor, grumbled, and were in all respects disagreeable.

Intelligent workmen do better work and give less trouble than ignorant men.

I am so well satisfied of the inestimable value of education to the laborer that I would make it compulsory. No man should be allowed to go into the arena of life unless he has at least a decent English education. A class of uneducated laborers in a community or State is an ever-present element of danger and injury, not only to labor, but to the State itself; therefore, sir, I am much pleased to see that you are collecting statistics for the information of the Government and people on the subject.

Another valuable opinion is that of Cyrus Mendenhall, President of the Kenton Iron Company, Newport, Ky.:

I rejoice that the official attention of the General Government is being turned to the subject of your inquiries, and cannot but hope that, sooner or later, it will result in some practical benefit to the country. The want of a higher grade of instruction in the science of their business for the managers of the different departments of the manufacture of iron—say in mensuration, geometry, the mechanical powers, hydraulics, hydrostatics, chemistry, etc.—has been severely felt by proprietors. The want of competent men in such positions often, I believe, makes the difference to owners between success and failure.

The want of technically educated workmen often makes the difference between success and failure of an industrial enterprise.

A. J. Mundella, Esq., member of the British Parliament for Sheffield, England, who had employed a large number—as many as three or four thousand at a time—in the middle counties of England, as knitters, weavers, finishers, and machinists, wrote to General Eaton as follows:

I would say that an educated man invariably acquires a knowledge of his work with greater facility, and executes it with less cost of supervision, than an uneducated man.

The mere rudiments I do not rank very high. If a man can barely read and write he has not attained to much. To read and write fluently is a great advantage in conducting the ordinary affairs of life. Evidence has been given before the British Parliament from my own districts showing that grave mistakes in chemical processes, such as bleaching, dyeing, etc., are constantly occurring through the ignorance of the workmen, they not having the ability to read writing. I have often witnessed natural powers in a person entirely uneducated which would

have been turned to the benefit of himself and his employer if he had only received a thorough elementary education. I have recently seen in Massachusetts, Englishmen whose wages their employers would have willingly doubled, by appointing them overseers, if they had only been educated sufficiently to keep accounts. I think it is impossible to estimate how much education would increase the value of their services. If the labor is merely mechanical, such as tending a machine that is making so many revolutions per minute, it requires little education to perform it; but if the labor is something where the whole manipulation depends upon the intelligence of the workman, it is a very different thing. The division of labor in England is so minute that the artisan who begins and continues the same work for years becomes a mere machine himself. The value of education, both to the workman and employer, is something that it is exceedingly difficult to estimate. The educated man will better understand the influence of those economical laws upon which his art depends than the uneducated; and my observation leads me to the conclusion that many of the strikes among workmen are the consequence of gross ignorance on their part, and that almost invariably the outrages and intimidation resulting from strikes are the acts of ignorant men. The more flagrant cases of violence and intimidation in England have been in connection with those trades unions where the education of the workman has been grossly neglected.

I believe that technical education is of great importance; that the success of Switzerland and Germany in manufactures, and their superiority over others for the last thirty years, have been owing to the excellent elementary education they have given to their workpeople, to which has been superadded, with great advantage, in my opinion, a large amount of scientific and technical education. Art training in England has exerted a marvelous influence in improving the designs for every description of manufacture in which taste is required, and consequently in increasing the demand in foreign countries for such manufactures. For example, the result is seen in better styles of carpets, laces, dress goods, crockeryware, furniture, ornamental iron work, and in every manufacture where decorative art is of value. I think the great want in this country is such education. I have known instances where a youth who has received art training has been able, at twenty years of age, to earn more than all the rest of the working force of his father's family. There is one case among my own workmen where such a lad is getting very high wages, and the effect is that the whole household is elevated.

The greater the improvements in machinery, the more intelligence is required on the part of the workmen who manipulate it. It has been found in England that for working the improved agricultural machines a higher class of intelligence and skill is required to manage them than the old peasantry possess. An intelligent workman will always produce a larger amount of work from a clever machine than an ignorant man can, and will keep his machine in better working condition.

* * * * * * * * * *

Certainly, I should prefer those who had the very best education for responsible situations. In my opinion a youth cannot be too highly educated for business purposes. I believe there can be no greater mistake than the old and common error that a boy may be made above his business by education.

My experience of workmen, on the average, is, that the better a man is educated, and the greater intellectual resources he possesses, the less is he disposed to sensual indulgence, and the less inclined to any kind of intemperance and excess. Those trades most characterized by intemperance in England are those wherein the workmen employed have the least education. I have employed in various departments of my own business intelligent workmen earning lower wages than ignorant men employed in coarser branches of the business; and the intelligent man educates his children, lives in a comfortable house, and has much refinement and many pleasant surroundings; whereas the ignorant man, with higher wages in some other department of labor, is more addicted to intemper-

ance, his wife and children are worse clad and worse cared for, and his home, in all respects, is less comfortable. Perhaps the best illustration of this would be the contrast between a clerk earning £80 a year, who is a gentleman in education, tastes and surroundings, and an ignorant laborer earning the same sum. In England intelligent workmen are generally the men who are distinguished for economy and thrift. They take the lead in all useful associations; they are the managers of the mechanics' institutions, the teachers in the Sunday-schools, and the founders of co-operative societies.

In the same connection Mr. John W. Browning, bricklayer, President of his trade union and Secretary of the National Labor Union, New York City, replied as follows:

I have not infrequently worked with members of my trade who have labored years at the business and yet remain ignorant of the simplest, though very important, materials in the building line. For instance, anchors are fastened to every fourth or fifth beam, and must be, or should be, well secured in the wall, by which means there is a bond between the two walls, or four walls, as the case may be; the walls are strengthened, the building is firmer and less liable to settle. The men I allude to build around and over these anchors, wondering what they are there for and paying no regard to security. Such mechanics are half their time unemployed, and they attribute it to hard luck, or something of that kind; but they do not seem to take heed and get on, and they become discouraged. But it is not so with the mechanic who understands the theory of his business, or who has studied sufficiently to discipline his mind. He understands, or will understand, that the anchor must be set snug in the wall. He knows why a fireplace is built on the outside of a gable. He knows what a keystone is for. In short, he knows the uses of the materials and the designs of the specifications, and he is able to earn his wages, and in many cases superior wages, besides enjoying steady employment during the building season. The latter class of our trade are the students of our business; they lighten their labors and the labor of others by new inventions. A year ago 1000 brick a day was considered a fair day's work. It is the basis of estimate at the present time; and yet an ordinary bricklayer can lay from 1500 to 2000, while I have known men to lay 3000 a day on a twelve-inch wall. I think any one who has adopted any means to discipline the mind, either by studying at school or elsewhere, is preferred to one who never gave himself to reasoning.

In my business a foreman, superintendent, overseer or journeyman cannot know too much, and those who are entrusted with the plans are skilled and as intelligent as can be had.

* * * * * * * * * *

I am in favor of free day schools for the children, free night schools for apprentices, free libraries and reading-rooms for all who wish to avail themselves of their benefits; believing that it will add to the industry of the nation, elevate society, and make us, morally and religiously, a better people and better citizens.

Exhibit Q.

Mr. Mather wrote letters to several prominent educators of the United States, asking what effect the educational institutions with which they were connected were having on the commerce and industries of the nation. A few of the answers that he received are inserted here.

LETTER FROM PROFESSOR TROWBRIDGE.

School of Mines, Columbia College,
Corner 49th Street and 4th Avenue,
DEAR SIR: New York, October 30, 1883.

In answer to your question, "What effect is the School of Mines exerting on the professions and manufacturing industries of the country?" I will just state that my answer will apply, I am quite sure, to all the institutions in this country in which the applied sciences are thoroughly taught, and where, at the same time, proper instruction is given in the technical applications of these sciences to civil and mechanical engineering, and to the agricultural, mining and manufacturing industries.

The effects produced on these professions and industries are felt more and more each year, in the attainment of *greater economy* in production, as well as in new and progressive developments in engineering practice, and in the principal arts and industries. These effects are accompanied by, and perhaps are largely due to, a general diffusion of scientific knowledge among the people. All classes are becoming impressed with the value and importance of national scientific methods, especially when they learn that these methods harmonize with the results derived from experience and observation. The knowledge thus diffused is fast breaking down and destroying the false antagonism—formerly supposed to be radical and insurmountable—between *theory* and *practice*.

The business man is becoming a better judge and critic in matters of science and engineering applicable to his own affairs, while the farmer, the artisan, and even the common laborer, are learning that in proportion to their increased knowledge of true scientific processes their labor becomes more efficient; they can secure better results at less cost and with greater certainty than formerly.

You can readily understand that bringing scientific knowledge, even in its elementary forms, to bear on industry in this manner, promotes material progress and growth, and secures public confidence in enterprises or improvements which receive the sanction of well-educated scientific men.

For this increase and diffusion of knowledge and this public confidence we are indebted largely to our scientific schools, and to the men sent out from them. I need only suggest the direct influences which these men exert through their own labors when they are scattered through the country among the mines, the manufacturing and engineering establishments, and the engineering works in progress.

Very truly yours,

Mr. W. Mather. (Signed) W. P. TROWBRIDGE.

LETTER FROM DR. HOMER T. FULLER.

Worcester Free Institute, Worcester, Mass.,
MY DEAR SIR: October 25, 1883.

In reply to your inquiry as to the effect of the training given at the Worcester County Free Institute of Industrial Science upon the industries of the country, it may be said that the school was not founded to create new industries, nor specially to build up those that were waning. It has helped to meet an increasing demand for men who were trained in both the theory and applications of science, and who, hence, could assist in developing and promoting enterprises requiring more than ordinary intelligence and skill.

It educates mechanical engineers, civil engineers, chemists and designers. Fifteen per cent. of its graduates are partners in business firms or superintendents of important business enterprises; 20 per cent. are foremen or draughtsmen, chiefly in shops for construction of machinery; 7 per cent. are skilled workmen in such shops; and about 20 per cent., comprising most of those trained in civil-engineering, are employed either in railway construction or in other civil-engineering work. Fifteen of them have filled responsible posi-

tions on a single railroad; six on another road. Besides these, the chemists have done good service in dye works and metal works, while about 10 per cent. of the whole number, including most of those who have given special attention to drawing and designing, have become teachers. Its graduates have usually quickly found employment, and some have been offered remunerative situations before completing their course of study.

It should be mentioned that this school is yet young, none of its graduates having been in practical life over twelve years, and the majority only four or five years.

The educational influence of the school has been considerable. Several other schools recently founded, or now projected, are adopting substantially its plans and methods of training. Such are the Rose Polytechnic at Terre Haute, Indiana, and the Miller School at Batesville, Virginia; and a committee of the Legislature of Georgia, after visiting the more important of the technical schools in the North in July last, reported a bill providing for the establishment of a State technical school, in which the course of training was indicated to be "as nearly as practicable like that of the Worcester Free Institute."

I am, etc.,

Wm. Mather, Esq. (Signed) HOMER T. FULLER,
Principal, etc.

LETTER FROM PROFESSOR GREENE.

Rensselaer Polytechnic Institute, Troy, N. Y.,
October 22, 1883.

MY DEAR SIR,

I have to acknowledge the receipt of your kind letter of the 19th instant, containing a request that I send you a brief reply to your inquiry as to what is my opinion and experience of the effect exerted by the training in this institution upon the engineering works of this country.

It gives me great pleasure to comply with your request.

The Institute was the first school of its kind established in the United States. It was founded in 1824 by the late Hon. Stephen Van Rensselaer as a school of natural and applied science. Its founder, long a member of the Board of Canal Commissioners, had been actively interested and largely instrumental in the construction of our first great work of internal improvement, the Erie Canal, which was completed in 1824. During the execution of this work there were no educated engineers in the country, and for this reason great difficulty was experienced in securing the services of persons competent to direct the necessary surveys, location and construction. Men were taken from various occupations and educated practically as the work progressed. Mr. Van Rensselaer thus had occasion to realize the pressing necessity of providing for the future requirements of the country, during the development of its vast and varied resources, a body of trained scientific men.

Engineering as a profession was unknown and, of course, unrecognized in the country. There were no railroads, no waterworks, no great bridges, and but few works of any description which could properly be called engineering works.

At such a time and under such circumstances the Institute was founded. During the 60 years which have elapsed since its foundation it has been closely identified with the marvelous growth and development of our country. From 1824 to 1840 its graduates largely became professors, geologists and manufacturers, a few only entering the field of engineering, for the reason probably that there was only a small demand for engineers.

With the introduction and growth of railways and other engineering works there came an increased demand for engineers, to meet which, in 1850–51, the course of study and practice at the Institute was modified and enlarged to meet

existing and future requirements; and it then became exclusively a school of civil engineering.

About this time and for the same reason engineering courses were established in various colleges, and since that time many technical schools have been organized throughout the country, all based upon the same general plan, and all owing their origin to the rapidly growing demand for, and the more widely and generally recognized importance of, technical education.

At the present time there is scarcely a State or a Territory which has not its engineering or technical school.

The Institute has furnished many professors for these institutions. As a rule, however, the graduates of the Institute enter at once upon the active duties of the profession of civil engineering, in which very many have become eminent, not only as designers and constructors, but as managers of great railway and manufacturing corporations, while many others are growing up in various subordinate capacities, and are thus becoming fitted for the more important and responsible duties of the profession.

The field of engineering is rapidly widening, and the specialties of hydraulic, steam, bridge, mechanical, mining and electric engineering have been promptly entered upon and occupied by the graduates of all our technical schools. In all of these the reputation of the Institute is nobly sustained by its graduates.

I believe it is not too much to say that the marked success of every educated and thoroughly trained engineer, in any branch of the profession, creates a demand for, and supplies, three more having similar qualifications and for similar service.

Although our numbers are constantly increasing, there are times when we are quite unable to respond to applications for our graduates.

You, my dear sir, have had an opportunity to see something of our country, and to become acquainted with its enormous extent and resources. You have seen its public works, and have learned much in relation to its manufacturing and mining industries. You have also witnessed the activity and enterprise of our people. Wherever you have been, and whatever you have seen in our country, whether it be the great structure spanning the East River between New York and Brooklyn, the steel arch spanning the Mississippi at St. Louis, the Pennsylvania Railway (the model railway of our country), or the public works of Boston, New York, Brooklyn, Philadelphia, St. Louis, and other cities, you have witnessed, and can yourself bear testimony to, the effect of the training in our institution upon the engineering of our country. We cannot, and of course do not, claim exclusive credit for these or other important engineering works. We merely represent that the Institute has been and is represented in all of them. I therefore state, in conclusion, that experience justifies me in expressing the decided opinion that the training of the Rensselaer Polytechnic Institute, as well as that of other similar schools, has exerted a most marked and important influence upon the engineering works of America.

I am, etc.,

W. Mather, Esq. (Signed) W. M. Greene,
Director, etc.

Exhibit R.

Extracts from Mr. Mather's Testimony before the Senate Committee on Education and Labor, whose Report was published in 1885, and which contains much Valuable Information.

In answer to questions by Senator Blair, Chairman of the Committee, Mr. Mather said that he lived in Man-

chester, England, where he was the owner of extensive machine shops, and stated that he had been an employer of labor all his life. The purpose of his visit to this country was to ascertain, on behalf of the Royal Commission on Technical Education, what opportunities are offered to the people of this country and Canada to acquire industrial training and technical knowledge. Mr. Mather further testified:

Reasons for the appointment of the British Royal Commission.

The appointment of this Royal Commission to inquire into the technical education of all the countries in the world arose out of the fact that in England we have not many opportunities nor institutions which afford to our working-people, or even to our middle classes, the means of acquiring a knowledge of the sciences before they enter the usual occupations of life. We have felt for the last ten years very acutely, as you know, the competition which has sprung up in all parts of the world with English industries, and it has been supposed by some public men, and by large numbers of the community generally, that our manufactures of the simplest kind would for the future have to yield to a higher class of productions if we are to hold our place in the world as purveyors of clothing and the various articles which we have hitherto shipped from England. The countries of Europe have, of course, ceased to take from us gray cloth and the simplest forms of machinery, and in a hundred ways ceased to need our services in matters for which, twenty years ago, they were absolutely dependent on us.

In consequence of this we find it necessary to improve the taste in all articles we manufacture, and to bring to bear a higher knowledge of the scientific laws that underlie all the industries, and to educate our people into still greater skill—a skill derived from higher intelligence. Our opportunities hitherto, in England, to impart this sort of knowledge to our apprentices, and to men who desire to learn after they have entered upon the ordinary duties of life, have been very few, and have been of a voluntary character. On the Continent of Europe industrial and technical schools have been in existence—in Germany, France and Switzerland particularly—for a considerable number of years, and the benefits accruing from these have at last invited our attention.

The industries of England have flourished chiefly, hitherto, upon the great demand which all the world has made upon us for our products, and on the facility with which, owing to the abundance of material, we have manufactured all our machinery and textile goods.

During the last ten years that demand, as I have said, has very much decreased, and we have now to pass on to a different kind of manufacture. Our people cannot respond to this higher demand made on them. We have not had the art schools or science schools to enable them to understand the laws or principles upon which this higher industry is based.

In order to meet this, we hope to establish in all our manufacturing districts certain institutions—you may call them technical schools—in which not trades shall be taught, but the science that underlies every industry shall be imparted to the children of workingmen, at the same time that they are somewhat trained in industrial skill to manipulate, to pass through and understand the operations which are necessary for the various kinds of manufacture that we desire to improve.

* * * * * * * * * * *

I will give you my own case. I have a number of engineer apprentices in my own works. I felt the necessity of having these young fellows employ the time

Mr. Mather's Shop School.

more to their own benefit and profit, and also more to the interests of my concern, so we built a school inside the works and made it compulsory on every apprentice to attend that school during the evening two hours in the week. If they do not attend that school they are discharged from our employment; and this applies to all our apprentices.

Trade Unions.

I am happy to say that trades unions with us have become part and parcel of our life. We have accepted them now as one of the proper societies for the working classes to form, and, conducted as they are by able and, I think, in the main, conscientious and respectable men, we have joined with them rather than separated from them. Employers of labor generally have lost that violent antagonism which, you know, existed at one time; the trades unions have moderated many of their demands, and whatever demands they now make, they at any rate make in more moderate language and in more polite ways. The capitalists and laboring population have both learned by experience, and, I think I may say, have come to see that none of the interests of capital or labor can be served when there is an antagonism between them. On the other hand, I think the laboring classes see that capital has certain difficulties and trials and experiences of which laborers know nothing, and by frequently comparing ideas, as we do under the arbitration courts that are sometimes established between masters and workingmen, a great deal of information is passed from one side to the other.

Strikes are not violent.

The consequence is that our strikes now, though they may be long, are not violent; though they may be stubborn on the part of the men, who will not see that trade is in such a state that higher wages cannot be granted; or, on the other hand, on the part of the masters, who have their own stubbornness sometimes, and try to withhold from the laboring-classes the amount of wages they ought to give them when trade has improved. While these two positions will always, of course, to some extent, exist (for there will always be some obstinacy on both sides), yet, as a rule, violence and passion have departed from those disputes, and all questions are settled with good feeling.

In all trades, aside from the textile industries of our country, we have for many years been, for the most part, entirely free from strikes. In all engineering difficulties, disputes have been settled freely and without any ill-feeling. The engineer class with us are the most intelligent, and therefore the most reasonable. The engineer trades with us include pattern-makers, moulders, smiths, fitters, turners and directors of machinery—everything connected with machinery we call engineer trades.

The building trades have a strike occasionally, but, compared with the number of differences that they settle by arbitration and conference, the strikes are not of much importance. They have had long-continued disputes from time to time, but, as I have said, there is no violence connected with them. After a certain amount of suffering on the part of the men (for, unhappily, it generally terminates that way with us), the difficulties are settled and they go to work. I think we have bridged over many difficulties by this simple remedy of arbitration. We have lessened the hours of labor, and have brought nine hours a day to be the standard, instead of ten hours a day. Employers generally have endeavored to show a sympathy with the social life of all our working-people by establishing provident dispensaries for their succor or assistance when either injured in their work or stricken down by disease. We have nurseries, institutions carried on under the superintendence of our wives, who go down into the lowest parts to find and aid distress. This is common to every manufacturing town in the country. The wives of the manufacturers, merchants, and employers generally have found that the lives of the people, after their hours of work are over, are matters of their highest regard for the sake of their own interests. Hence various institutions have been established by public subscription and are managed by the manufacturing class for the benefit of the laborers.

Labor difficulties avoided by employers manifesting a practical interest in the welfare of their laborers.

You may readily understand that any virtuous and good act brings its own reward. That is an axiom that we have all accepted. But when I spoke of their interests, I meant that from quite a material point of view, leaving out the phil-

anthropic motives and the higher relations of men, and speaking of it merely as a matter of business. Wherever the employers of labor have manifested this interest they have found it to be of advantage in a business point of view. Whatever difficulties might arise between them and their employes in consequence of wages have been more readily adjusted, and, at any rate, the motives of the manufacturers are not misunderstood. The men only require to be convinced of the exigencies of trade, and to see that the thing which is stated to them is really true, to induce them to yield. This sympathy, this endeavor to elevate and improve the working-classes all round, sometimes by individual manufacturers, at other times by manufacturers combining together to make a district the centre of some means of reaching and improving the working-classes, is having the most excellent effect.

Material interests of employers are thus advanced.

For example, the establishment of coffee-houses, all over our cities, to form a sort of antidote to the public-house, to give workingmen a nice room in which they can meet their fellows and sit in comfortable chairs and have a smoke and a talk together, and an opportunity to take this harmless beverage and creature comforts of that sort, to the exclusion of spirituous liquors—all that has had a great effect. The public parks have also helped. The musical entertainments in the open air during the summertime—many of them encouraged by our corporations and supported largely by the employers—all that work is well-directed outlay for the enjoyment of the people.

Coffee-houses, public parks and musical entertainments.

The reduction of the hours of labor from sixty hours to fifty-four has allowed all the working-people to have a holiday, leaving their work on Saturdays at 12 o'clock. It gives them an opportunity to make their purchases in the daytime, and to take their children out into the parks and enjoy the fresh air. The working-hours are such that the workingman has practically got daylight all through the year for his work, and then during the summer months, of course, there are long evenings of daylight, and the half hour less labor at each end of the day gives the workingman an opportunity to wash, and covers the time when he would be going home, and is a great consideration to him. In consideration of this extra time allowed for recreation, we find that men are attending reading-rooms more than they did.

Hours of labor per week.

We have free libraries and reading-rooms established in each ward or district of our towns. If the ward is very large we divide it into districts and establish a reading-room which does not cost much money (three or four thousand pounds), and there we keep the papers of the day and scientific and literary periodicals and some standard books, and we find that the working-people are appreciating these advantages just in proportion as they get more time to devote to them. They have more leisure now, and many take advantage of their time to pursue some studies.

Libraries and reading rooms.

And because of this, we think our evening science schools, which we are endeavoring to improve, will be better attended, and we shall therefore get some science and art teaching into the adult working-classes who have already begun their life-labor, who have almost always the desire to become better informed, and will in this way be able to satisfy that desire.

Evening Science Schools.

If you will allow me to, I should like to make another remark as a result of my observation in America. I do not wish to say anything to intensify differences of opinion, but, having said it to several employers of labor, it may not be inappropriate to say it here. I believe that all American working-people have greater activity, greater nervous energy than our people have, and I believe they do more work, and can do more work, from that spirit of intense desire which they have to accomplish something, to accomplish more, even, day by day, than they have done before. This is the spirit of your people. They work harder while at work, and I therefore say that nine hours of labor here, with the intensity of diligence which your people display, would, I think, count for more than ten hours of our people's work. Undoubtedly the condition of the working-classes in this country is superior to ours, all round. The very fact that you have food just as cheap as we have it—in some places they say it is cheaper, but at any

Hours of labor in America.

rate it is just as cheap as our working-people enjoy—that you pay wages varying from one-half as much again to double as much again for similar employment; that you have or have had, hitherto, as I think, more constant employment than our people have, and therefore the aggregate earnings in the whole year are greater than they are with our people—all these indicate that there is more purchasing power in the hands of the American workingman than an English workingman enjoys.

High rents in America.

The one subject which strikes me as being very difficult to comprehend, and most oppressive, I think, upon your working-people, is the enormous amounts they pay for house-rent. I do not think I overstate the case when I say that rents are double, all through this country, for the same degree of comfort, that they are in England. That is so even in Pullman City, which is a model city. It has always struck me as being a very remarkable and almost unnatural condition of things that in a country where there is so much land, and where the resources of the people are so much greater, and material therefore ought to be so cheap, the habitations of your working-people cost so much. It is certainly an indisputable fact that rents are double here what they are in England.

In this country waste of raw materials is the normal condition of things. You waste your forests, your metals, your food and your drink. There is so much waste here that it is not noticed.

All the institutions for the aid of the working-people are kept up by the employers—all our hospitals and dispensaries—to give cheap medical advice and cheap surgical aid, and relief in time of need. We have workingmen's clubs established by philanthropic people; we have coffee-houses where the workingmen can come and read. Into these, members of the committee come from time to time, and take an interest in the young people.

I think what you require here is a larger interest in the working-classes by your wealthier people. You require more institutions for their intellectual enjoyment, for their entertainment and their recreation. You require less hours of labor, certainly.

I think you ought to reduce your hours of labor to nine—it would be for the benefit of the whole country, employers and employes—so as to give a full, solid half-holiday each week for the entire mass of the working-people. They would enjoy family life more, and would have less temptation to indulge in vicious habits.

Industrial training should be introduced into the public schools.

Then, in your common-school system, by introducing industrial education side by side with intellectual education (and it would not hurt intellectual education, but would help it), you would have a larger number of people who would be willing to go out into the far West, and, meeting the forces of Nature, subdue them in a territory that is apparently unlimited and as rich as it is boundless. All that spirit would be evoked by these simple changes, which would be very easy to make. It would only require probably the resolution to do it, and it would be done.

Comparison between the condition of American and foreign workmen.

In all other respects the working-classes of this country are infinitely better situated than any people abroad. They have in their form of government no hindrances of any kind, either from tradition or feudalism; they can acquire land easier—it is almost given away in many parts of this country. They have an equality among themselves and their foremen and managers that you do not see in any part of the world. I am particularly struck by the respect which the managers and foremen here seem to have for their workmen, the civility they show them; all of these are advantages to the workingmen, apart from their civil rights, which, of course, are universally admitted here; all these make up a social condition superior to anything we have in England. And if the working-people were only by their habits to show that they were capable of taking the advantages offered them by Nature and by your free institutions, they ought to be the happiest and most prosperous people in the world. Government need do nothing more for them, I think; but society requires to do a great deal more for them.

Public opinion should be directed toward the amelioration of the condition of the laboring classes.

I have heard a gentleman say here that corporations were not distinguished for their sympathy. That is true; and that is why I point out that society in America, in all the great centres of industry, has a duty laid upon it that I think it is not performing in the full sense of its responsibilities. In these great corporations the shares are held, I presume, by wealthy persons, representing probably the culture of your cities, and probably occupying public positions. It would be a very simple matter for any of those corporations to appropriate, by their shareholders, from year to year, such amount of money as they might wish to appropriate for the benefit of the working-people. And if public opinion in this country were directed toward the amelioration of the condition of the working-classes all around, it would not be an uncommon thing for certain sums of money, probably every year, to be given for their benefit. That is not uncommon with us. We are tending somewhat ourselves, you know, to turning all our concerns into joint-stock companies; but I am very happy to be able to say that we often find that spirit of humanity among our corporations—not so much, perhaps, as with individuals, but there is coming, more and more, to be an acknowledgment of the fact that any employer of a large class of people is bound to regard those people on the social side as well as the industrial side.

Exhibit S.

EXTRACTS FROM AN ADDRESS ON TECHNOLOGICAL INSTRUCTION, BY PHILIP MAGNUS, SECRETARY AND DIRECTOR OF THE CITY AND GUILDS OF LONDON INSTITUTE.

Workmen, generally, make a great mistake in taking a very narrow view of their own educational requirements. Instances of this are continually coming under my notice. It is difficult, for example, to make them understand that a knowledge of intimately associated and cognate branches of their trade is likely to prove serviceable to them; that in order to become efficient foremen it is necessary that they should possess an intelligent and comprehensive acquaintance with the entire area of the work in which they are engaged. It is partly to correct the cramping influence of the extreme division of labor that technical instruction has become necessary.

Speaking from my own experience, I should say that workmen generally care to learn in the school very little more than they might learn in the shop; they only want to learn it more quickly. This desire of workmen to learn those parts only of a subject which seem to them to be intimately connected with their special occupation reminds me of a fact told me by a medical friend, that among his students of anatomy was one who expressed his decided unwillingness to dissect the abdominal cavity, because, as a surgeon, he intended to devote himself exclusively to diseases of the eye. This narrow view of the scope and objects of technical education needs to be steadily and persistently discouraged, and it is one of the objects of this college to bring home to the workman the advantages of a wider and more comprehensive system of instruction.

A similar difficulty is experienced in inducing adult artisan students to attach sufficient value to a knowledge of the elementary principles of the sciences bearing upon their industry. This is due partly to the method of science teaching commonly adopted, which does not distinguish between the requirements of school-children and of adult workmen, and partly to the fact that such students are too impatient to see the immediate applicability, at each successive stage, of the knowledge they are gaining to their particular work. It is possible that the fundamental principles of science are not always presented to the artisan student in as attractive a form as they might be, and that he is not made to see, at a sufficiently early stage, the connection between the instruction he is receiving and the occupation in which he is engaged; but of the value and the importance of this elementary knowledge as preliminary to, and as an essential part of, technical instruction, we must take care never to lose sight.

These and other difficulties will doubtless be found to gradually disappear in the training of young apprentices, who will constitute the workmen of the future, and whom, in the interests of trade, quite apart from the material advantages which they themselves may derive from such instruction, it is most desirable to carefully educate. In Belgium, and in some parts of Germany, where technical teaching is better systematized than in this country, the class-rooms, in the evening, are filled with young students who attend five or six nights a week and follow the several courses of instruction in the order in which they are recommended to them; and, in the hope of being able to introduce a somewhat similar system into this college, courses of instruction have been arranged, adapted to the requirements of apprentices engaged in various industries, but affording, at the same time, an education in the true sense of the word. These curricula have been drawn up with special reference to the educational wants of the mechanic, the electrician, the metal-plate worker, the cabinetmaker, the carpenter, the bricklayer, the plumber, etc., and are intended to supplement without interfering with his workshop training.

In the ordinary teaching of pure science the preliminary stages of instruction are such as afford, or are intended to afford, the best basis on which the superstructure of higher knowledge can afterwards be raised, and where the pupil has a long course of study before him, to which he can devote himself before being required to apply his knowledge to any special art or industry. No better method of instruction can be devised.

But the case is different where the pupil's period of study is necessarily limited, and is not long enough to enable him to attain to that higher knowledge which would justify the time spent in preparation for it. Indeed, in this respect, the practical educator may take a lesson from the builder, who adapts his foundations to the superstructure to be raised upon them. This question of time is an important factor in the consideration of all schemes of technical instruction necessitating the early specification of the student's work. For we may take it for granted that the pupil requires not only a knowledge of the principles of science and of the details of practical work, but the ability to apply the one to the other; and for this reason it is essential that theory and practice should be combined in his instruction, and that both should have reference to his particular work.

In this college all the subjects of instruction will be taught, as far as possible, with reference to the career or occupations of the students; that is to say, the teacher will keep steadily before him the purposes to which the student will apply his knowledge in the instruction which he gives him. Indeed, the technical teacher ought to be so constituted as to be able to keep one eye on the general principles of science, and the other upon the industry which his pupil intends to follow. Instruction of this kind must overlap ordinary science teaching and the teaching of a trade, and must yet be distinct from either. Between the ordinary, or the scholastic, teaching of the elements of physics, and the instruction, for example, that might be given to a novice in the manipulation of a telegraphic instrument, there is a wide difference; and it is within this difference that a technical teacher is called upon to do his work. So, too, between the teaching of Euclidian geometry and the rules that would be given to an apprentice for the construction of a particular kind of joint, or the cutting out of a sheet of metal to a given pattern, lies the border-land for technical instruction in the application of geometry to joinery and to metal-plate work.

Speaking generally, the method of teaching science in this college will be based on the well-known educational principle that all teaching should proceed from the concrete to the abstract, from the known to the unknown. The student will be brought into contact, first of all, with the actual working machine, and he will then proceed to analyze it into its different elementary parts, and to deduce the laws of their action. In this way the principles of science will be derived from the mechanical contrivances exemplifying them, just as the laws of growth and decay are inferred by the student of biology from the observations of living

animals and plants. This method of science teaching has been tersely described by Professor Ayrton as the analytical, as distinguished from the synthetical method; and it is satisfactory to know that in this college it will receive a fair trial. To the adult student the advantage of this system of instruction must be plainly manifest, for he, being already familiar with the general character of the machinery he uses, will arrive at a knowledge of the abstract principles of science by a natural and easy method of inquiry into the causes that explain the processes he sees; and, apart altogether from the material advantages he may derive from this higher knowledge, he will be enabled to reach the state of happiness ascribed by Virgil to the similarly educated agriculturists,

"—*qui potuit* rerum cognoscere causas."

It is scarcely necessary to add that the teaching in this school will be essentially practical; that more will be done in the laboratories, in the drawing-rooms and workshops than in the lecture theatres. Indeed, it may be rather said that the lectures will form a commentary on the practical work than that the practical work will serve only to illustrate the lectures.

It must be remembered, in considering this difference of method, that the main purpose of the teaching to be given in this institution is not to make scientific men, nor to train scientists, as the Americans call them, but to educate technikers, as the Germans say; to explain to those preparing for industrial work, or already engaged in it, the principles that have a direct bearing upon their occupation, so that they may be enabled to think back from the processes they see to the causes underlying them, and thus substitute scientific method for mere rule of thumb. It is almost superfluous to remark that instruction of this kind can be given by those only who possess a wide and deep knowledge of their subject, and a full and accurate acquaintance with the practical and commercial details of the industry or trade to which their teaching refers. Indeed, it is now generally recognized that technical teachers must be familiar with the processes of the factory or workshop. Teachers of this kind the President of the British Association must have had in view when, in his opening address at Southampton, contrasting them with the ardent students of Nature, the "High Priests of Science," he said: "It is not to them that we must look for our excellence and progress in practical science; nor must we look for it to the rule-of-thumb practitioner who is guided by what comes nearer to instinct. It is to the man of science, who gives attention to practical questions, and to the practitioner, who devotes part of his time to prosecution of strictly scientific investigations, that we owe the rapid progress of the present day." Such men, of whom the writer himself is so illustrious an example, are difficult to find; and yet the progress of technical education in this country depends upon their supply.

The teacher who is to inspire confidence in his artisan students must address them in the language they understand, and must show that he is not beyond appreciating practical difficulties which occur to them in their daily work. Dr. Siemens further tells us that "theory and practice are so interdependent that an intimate union between them is a matter of absolute necessity for our future progress"; and certainly none are more alive to the truth of this proposition, as regards educational progress, than artisan students, for it is to them a constant source of regret that they are unable to see the relation of scientific truths, as they are generally imparted to them, to the work in which they are engaged; and in this complaint, which is so often heard, is found the protest of workmen against the divorce of practice from theory in the instruction which they frequently receive. With the view of indicating the requisite qualifications of the technical teacher, the Council of this institute have inserted in their programme of technological examinations a paragraph stating that persons having a practical acquaintance with their trade, acquired in the factory or workshop, and possessing, at the same time, such knowledge of pure science as enables them to teach under the Science and Art Department, will be registered as teachers by the institute.

Of the four departments into which the college is divided, that of electrical

engineering promises, for some time at least, to be the most attractive to students. The applications of electricity to telegraphy, telephony, illumination, machinery and locomotion are among the most recent of the practical developments of science, and seem to afford a glimpse, if nothing more, of the wider field of invention which is yet to be explored. The appetite for wonders grows with what it feeds upon, and never before, perhaps, was the world more willing to believe in the possibilities of science than now. This universal credence almost constitutes a new faith. The numerous discoveries fetched within the last few years from the seemingly boundless world of physical science verify and give a special significance to Cicero's words:

"*Omnibus fere in rebus, et maxime in physicis, quid non sit citius quam quid sit, dixerim.*"

Although electricity may be regarded, just at present, as the most popular of the sciences, the discoveries which have recently been made in other branches of knowledge are scarcely less important. The skill and the inventive power of the mechanician have been called into requisition with every advance in physics and in chemistry. Indeed, it is only when the inventions of physicists and chemists are capable of being adapted to machinery that these inventions can be said to be practically serviceable. The great discoveries which have recently been made in chemical science, in the application of which to industrial purposes the Germans and the Swiss have left us so far in the rear, are among the causes that have given rise to the demand in this country for the technical instruction which the City and Guilds of London are engaged in providing. It may reasonably be supposed that many of the students of this college will entertain the laudable ambition to have their names enrolled among those who have pushed discovery one step further, and have added something to the sum total of human knowledge; and it may be encouraging to these students to be told that they will here receive a preparatory training that should help to place the power of discovery within their reach. For discovery in science, like design in art, does not depend entirely upon, although it is greatly aided by, inspiration and genius. Any one who is carefully trained in the methods of research, who is shown the processes by which the system of organized knowledge, known as science, has been gradually built up, may reasonably hope to unravel fresh secrets of Nature, and to add something to our knowledge of what is or may be. Except, perhaps, in the region of chemistry, it is not the masters of acquired knowledge, the professors of abstract science, but rather those who have made science minister to art—practising first and then calling theory to their aid—who, as discoverers, have exerted most influence upon the material progress of the world, and have chiefly assisted in the development of its trade and commerce.

Exhibit T.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—SOCIETY OF ARTS.—EDUCATION FOR RAILROAD ENGINEERING.

The 351st meeting of the Society of Arts was held at the Institute of Technology on Thursday evening, Oct. 28, President Walker in the chair.

After reading the records of the previous meeting, the President introduced Mr. C. D. Jameson, of the Institute, who read a paper on "Railroad Engineering Education."

Mr. Jameson said: "The duties of the first railroad engineers were much more general than those of the present engineers. They located and built their railroads, designed their locomotives, rolling stock and bridges, and when completed managed the road with success, and this without the aid of experience or precedent. Usually they were men who had had no early education or training in railroading, but possessed an indomitable will, unlimited patience and a good stock of common sense.

"We undoubtedly do things more quickly now than then, and in many respects do them better; but this is due to the fact that we naturally profit by their experience, and also at the present time no one man does the whole of anything, hence he can do his particular part better.

"In many branches, however, we have made little, if any, advancement. This is particularly the case in the matter of location, where we seem to have copied the earlier engineers in their errors, but not in their habits of careful observation and study.

"The majority of our railroads are uneconomically located, and not only was the first cost of construction more than it ought to have been, but the loss in the operating expenses is enormous, and increases with increasing business. This loss is not, in the majority of cases, due entirely to the engineering profession, but to the mistaken policy on the part of the management of the railroad companies.

"The expenses of the engineering parties on preliminary work and final location are very great, and for much of this expense the management can see no direct return, and there seems to be an idea abroad that most of the money spent in this way goes for theory and is of very little practical use to the company. Therefore the salary of the locating engineer is comparatively small, and his ability is frequently small in proportion. The number of his assistants is kept as low as possible and the result is inferior work. The vital principles upon which the economic location of a railroad depends are not considered at all, or, at the most, in a very slight degree, and the smaller details upon which, to a great extent, depends the ultimate financial success of the road, are left entirely out of account.

"After the road is located the management secures the services of the best construction engineer possible. This is as it should be; but no matter how great may be the abilities of the construction engineer, or how much he may save in overcoming the defects in location, still the greater part of the money merely passes through his hands as a paymaster, having been actually expended months before by the locating engineer.

"In order that the railroad engineer of the future may be thoroughly competent, both in the 'theory of economic location' and in the details connected with the work in the field, too much attention cannot be paid to this branch of education.

"We are in an age of specialties. The engineering profession has been subdivided, so that we now have civil, mechanical, mining, hydraulic, sanitary, bridge and railroad engineers. In order to reach distinction a man must confine himself to his specialty, and if that be railroading, his time either as a student or as a man in active work will be amply filled in keeping pace with the age.

"There seems to be a tendency among certain classes to sneer at an education, considering the time that is spent at college wasted, and that it might have been spent to much greater advantage in actual work in the field. Many instances are cited by these people in corroboration of this belief of persons who have risen to the head of their professions by their own exertion, without the aid of a college or technical education, and also of a large number of men who, having graduated from our finest schools, have accomplished nothing. The reason for this is not that these unsuccessful men lost anything by going to college, but they were greatly inferior in energy and ability to the others. Colleges do not profess to make brains, but simply to teach the man to use what he has to the best advantage, and the man who is successful without a college or technical education would, with this aid, have found the path to success much easier and shorter.

"In the years which intervened between the first railroad engineers and those of the present they were considered a necessity in locating and building the road only. The road was then turned over to business men to manage. As long as the roads were small, and the repairs and renewals slight, this worked well. As the number of roads increased, and long lines and systems began to be formed, the increase of traffic demanded a large increase in the size and weight of the

locomotives and rolling stock; this in turn necessitated renewals and additions to the roadbed and track, the replacing of the old bridges by new and heavier ones. This reconstruction in the form of renewals will never cease, and with it all the railroad companies have come to see the necessity of a permanent and reliable engineering corps. Thus the field of work for the railroad engineer has broadened from the transient work of locating and constructing the road to permanent positions on established roads, where there are abundant opportunities of making good use of his ability. But in order to take advantage of all these opportunities there is need of a much broader education in what we may call 'railway science,' which includes many branches as yet very little taught in our technical schools.

"Let us now look at some of the items that should be included in a course of instruction in 'railway science,' or, as it is commonly called, a 'special course for railway engineers.' The length of the course should, if possible, be five years instead of four. The first two years should be devoted to laying a firm foundation in the general studies, particular attention being paid to mathematics, chemistry and physics in their more elementary forms; the third year to the general study of civil engineering, and the last two years to a special study of railroads in all their branches. The third year's course should contain thorough instruction and practice in the field work of the railway engineer, in both location and construction. When the weather will permit, the field work should be pushed even to the point of sacrificing some of the work in the class-room. The field methods should be taught exactly as they are now used in the best practice; the same terms used, the same organization of parties, and, most of all, the same discipline and strict attention to business. The greatest possible attention should be paid to the subject of location in all its details in the field, and when the student has mastered as far as possible the principles that govern a railroad location in regard to the geography of the country and understands the actual work of putting the line on the ground, then, and not till then, should he be instructed in those finer details and principles of the work called the 'Theory of Economic Location,' and upon which the true location of a railroad depends.

"This 'Theory of Economic Location' should be taught in the last two years. Also there should be given a course of instruction in every branch of railroad construction, which should contain an amount of hydraulic and sanitary engineering sufficient to enable the person to build and maintain stations, shops, etc., and the proper handling of all the water that may be encountered in the construction and maintenance of the road; the 'maintenance of way' in all its details, both in theory and practice; the proper management and economical distribution of large and small gangs of laborers; railway management as it applies to the operating of the road, such as internal management of the separate departments and their relations to the general management; the making up and running of trains; running and repairs of locomotives and rolling stock; station and terminal service; the relation between the railroad and the public; the financial management as to bonds, stocks, leased lines, consolidations, pools, etc.; and all the questions of railway transportation, legislative interference and State ownership.

"In the instruction in any branch of engineering the one thing to be kept prominently before the student is economy of design and construction. It is not enough to be able to design and construct a bridge of a certain length which shall safely hold up a given load, or a station that shall accommodate a given number of passengers and trains, but this should be done at the least possible cost.

"If a person examines the courses of instruction in the different branches of engineering in the various technical schools in this country, he will be struck with the antiquated ideas and methods that still prevail in a majority of them. With but one or two exceptions there is no instruction given in railroad engineering proper, and the merest outline of the principles of location and construction. There are undoubtedly some reasons why the schools are so much

behind the times, and one of the most common and at the same time the most serious is the lack of money. Another is the low standard of admission, in consequence of which the whole of the first year is occupied in teaching what ought to have been learned before entering. The standard of admission is often lowered to attract students, but it is a suicidal policy and soon ruins the reputation of the school. Every school should have an endowment large enough to pay all salaries and running expenses without depending in the least on the tuition of the students. Students should not be admitted until they are eighteen years of age, so that they will be able to fully appreciate the advantages offered them.

"Still another reason is in the fact that the faculties of many of the technical schools have allowed themselves to get into ruts, from which it is difficult to move them. With the exception of the first, these reasons may be classed under the head of bad management, and the trouble can be easily corrected.

"Every advantage should be placed at the disposal of the student. All the apparatus necessary for experiment of every kind should be provided; a good library containing every book of worth bearing on the different subjects; a good, quiet reading-room where all the engineering periodicals of the day are accessible. The student should be encouraged to do as much reading from a literary standpoint as possible. It teaches him how to think and to express his thoughts in a clear, logical and grammatical manner.

"He should be taught habits of application and the power of being able to concentrate the whole mind for the time being upon whatever work he has in hand. In other words, he should be taught to study so that when he leaves he will not only be able to profit by his own experience as it comes slowly, but, what is far better, to profit by the experience of others, and thus at once advance to a point which it would take him years to reach by himself.

"During the years spent at the Institute the student should examine as much as possible all engineering works that can in any way interest him while in process of construction.

"In conclusion, let me say that the student should be so drilled that when he graduates he can have not only the diploma of the school, but, what is of more importance to him, can accept any position in his profession that offers, prove himself of use, and therefore a necessity to his employer, and earn a living for himself."

The paper was followed by a lengthy discussion, in which President Walker, Professor Swain, Hon. J. A. Dresser, Mr. George R. Hardy and Mr. Dwight Porter took part. The meeting adjourned with a vote of thanks to Mr. Jameson.

Exhibit U.

BALTIMORE AND OHIO RAILROAD COMPANY,
GENERAL MANAGER'S OFFICE.

GENERAL ORDER No. 5. BALTIMORE, *January* 15, 1885.

EXECUTIVE ORDER No. 6, dated JANUARY 15, 1885, from the office of the President, is republished for the information of those concerned [see Exhibit A]:

In accordance therewith, the following general regulations governing the appointment, admission and service of Apprentices of the Baltimore and Ohio Railroad Company are announced, superseding all previous regulations relating thereto:

SECTION I.

1. On and after this date all Apprentices will be embraced under the following general designations, and graded into three classes—viz.:

1st (Junior) Class, B. & O. Apprentices; 2d Class, B. & O. Cadets; 3d (Senior) Class, B. & O. Cadet Officers.

2. The term of service in the several classes will be: First class, 4 years; second class, 3 years; third class, 3 years.

3. As the Baltimore and Ohio Railroad Company undertakes the expense of educating Apprentices and Cadets passing the physical and educational examinations, it will expect the privilege of availing of the services of such as are competent for its purposes, at fair salaries, for at least three years after graduation.

4. Apprentices and Cadets will be amenable to the discipline and regulations of the Company, and violation of its rules, neglect of its interests, destruction of its tools or waste of its property, will be cause for dismissal. But, while liable to suspension by their immediate official superiors, Apprentices and Cadets cannot be dismissed except by the direct action of the General Manager of the Company; his decision as to dismissal being final and conclusive.

5. The pay of Apprentices and Cadets in the several classes will be:

First Class.	Second Class.	Third Class.
1st year, $ .70 per day.	1st year, $1.00 per day.	1st year, $1.50 per day.
2d " .80 "	2d " 1.12½ "	2d " 1.75 "
3d " .90 "	3d " 1.25 "	3d " 2.00 "
4th " 1.00 "		

commencing with the date of their admission into the service. As an incentive for efficiency, fidelity, industry, energy, and care of its property, the Company will give to each of its Apprentices, on the completion of his term of four years' service in the first class, and to those Cadets passing through the full courses of the second and third classes, whose record for that time has been praiseworthy and satisfactory, a sum equal to eight and a half cents per day for each full day they serve in the first class, and twelve and a half cents for each full day they serve in the second class.

6. The Cadets of the second and third classes—and all students of the Technological School—will be required to wear in the School, on all public occasions, and at any and all other times designated by the General Manager, a prescribed uniform, all the parts of which will be of like pattern and will be furnished by the Purchasing Agent—the first suit free, and all renewals at cost price; payment being arranged in instalments to suit the means of the Cadets.

7. Apprentices possessing the qualifications and standard of attainments required of students of the Technological School at Mt. Clare, Baltimore, and all Cadets, are entitled to enter that institution. Students of the Technological School, either of whose parents have been in the employ of this Company for five consecutive years, are entitled to free tuition and use of text-books and apparatus. Other students, sons of employes of less than five years' service, are entitled to free tuition in the first class, and to tuition in the second and third classes at half the rates fixed for other students by the regulations of the Technological School. Apprentices and Cadets appointed outside the service, while under pay from the Company, will be charged full tuition fees for instruction in the Technological School.

8. Apprentices or Cadets of one class can, in the discretion of the General Manager, be promoted into a higher class before the expiration of the full term of their respective classes, on the certification by the Corps of Instructors of the Technological School of their having satisfactorily passed examinations entitling them to such promotion. Such examinations shall be graded, and those of higher grade shall first be promoted. But no Cadet Officer will be graduated until he shall have taken the full course of instruction of the third class.

9. In filling vacancies in the second class, other things being equal, preference will always be given Apprentices, in order of merit, over other outside applicants for such cadetships.

10. No appointment shall be made in the grade of Cadet Officers except from Cadets of the second class, in the order of merit, as certified by the Corps of Instructors.

11. On the completion of their courses, members of the several classes will be entitled to a final examination by a Board composed of members of the Corps of Instructors and Railroad Officials appointed for this duty by the President of this Company, and upon passing satisfactorily such final examination, will be awarded diplomas setting forth their qualifications and entitling them to preference over all other applicants not thus graduating, in appointments to the higher classes or in filling vacancies in positions of responsibility in the gift of this Company, as they may elect, and as the Board may recommend.

12. Regular attendance upon the sessions of the Technological School is obligatory upon all Cadets and upon all Apprentices located at Baltimore as the Board of Examiners may determine are fit to enter the School, and they will be equally amenable to the discipline and regulations of the School as to those of the Company.

13. Students at the Technological School will have the privilege of purchasing, in small instalments, such of the tools, implements and text-books used in the course of instruction there as they may desire and as may be deemed useful to them after graduation.

14. Apprentices and Cadets are required to become members of the Baltimore and Ohio Employes' Relief Association, the same as other employes, and are entitled to all the privileges of its Savings Fund and other features.

15. Through the Free Circulating Library at Mt. Clare, Apprentices and Cadets residing outside of Baltimore can obtain the free use of text-books and apparatus to enable them to follow the course of the Technological School.

APPOINTMENT OF APPRENTICES AND CADETS.

Section II.

1. Apprentices and Cadets are not bound by indenture, but those who complete satisfactorily the terms for which they are engaged will be given certificates of general character and ability.

2. The number of Apprentices and Cadets will be regulated by the General Manager, who, under these regulations, will have the exclusive appointment thereof and their assignment among the various departments and stations of the service. All applications for appointment should be addressed to him.

3. Other things being equal, preference in appointments will be given sons of employes of long and faithful service, and especially the sons of employes killed or disabled in the service. To enable the sons of employes to enjoy this privilege to its fullest extent, free transportation from points on this Company's lines nearest their homes, to the place of examination and return, is offered them; candidates paying their own travelling expenses.

QUALIFICATIONS OF CANDIDATES.

Section III.

1. Candidates for admission to the first class must be between 15 and 21 years of age, and to the second class between 17 and 22 years of age.

2. Candidates must, at the time of examination, be physically sound, of robust constitution, and generally free from any deformity, hereditary or acquired tendency to disease or infirmity which may render them unfit for the active service of this Company.

3. Candidates must be well versed in reading, writing, including orthography, in arithmetic, and have a knowledge of the elements of English grammar, and of descriptive geography, and of the history of the United States.

4. Candidates will be examined: *first*, by two Medical Examiners of the Relief Association, whose decision as to their physical qualifications shall be final; *second*, by one or more Instructors of the Technological School, whose decision as to their educational qualifications shall be final.

5. The Examining Boards will meet at Mt. Clare Station, Baltimore, on the first Monday of each month, when there are candidates for examination. No candidates will be allowed re-examination within three months of last rejection by either Board.

6. Candidates who pass the physical and educational examinations will be required to become members of the Baltimore and Ohio Employes' Relief Association.

[An illustration of the character of examination which applicants for apprenticeship will be expected to pass is appended to this order.]

SECTION IV.

1. In the order of seniority of examination, and as vacancies occur, candidates will be assigned to probationary duty in the particular branch of the mechanical or other operating department in which, through inclination or aptitude, as determined by their examination, they are most likely to succeed.

2. At the expiration of six months they will be re-examined, and those passing will receive warrants of appointment, and will be assigned to the respective classes their qualifications entitle them to enter. Those found to be specially advanced or apt will, with their consent, be detailed to duty at the Company's works, Mt. Clare, Baltimore, where, in the Technological School, they will have special opportunities for technical instruction.

SECTION V.

A Board for the examination and classification of all Apprentices now in the service is hereby convened. Messrs. —— —— and —— —— are designated as the members of the Board to conduct the examination as to educational qualifications, and the Secretary of the Relief Association will detail two Medical Examiners to serve thereon. The Board as thus constituted will immediately enter upon its duties.

The Board of Examiners will convene on the first Monday of each month at Mt. Clare, Baltimore, for the examination of candidates ordered before it by the General Manager. As the finding of this Board will be final, and as a sound body and constitution, good natural capacity and aptitude for study, industrious habits, perseverance and an orderly disposition, together with a correct moral deportment, are essential qualifications, candidates knowingly deficient in any of these respects should not subject themselves and friends to the chances of future disappointment by entering upon a career which, lacking these qualifications, they cannot successfully pursue.

B. DUNHAM, *General Manager.*

ILLUSTRATION OF CHARACTER OF EXAMINATIONS.

SECTION VI.

PHYSICAL EXAMINATION.

Every candidate will be subjected to a rigid physical examination, and if there is found to exist in him any of the following causes of disqualification, to such a degree as would immediately, or at no distant period, impair his efficiency for the active service of this Company, he will be rejected:

1. Feeble constitution and muscular tenuity; unsound health from whatever cause; indications of former disease; glandular swellings or other symptoms of scrofula.

2. Chronic cutaneous affections, especially of the scalp.
3. Severe injuries of the bones of the head; convulsions.
4. Impaired vision, from whatever cause; inflammatory affections of the eyelids; immobility or irregularity of the iris; fistula lachrymalis, etc., etc.
5. Deafness; copious discharge from the ears.
6. Serious impediment of speech.
7. Want of due capacity of the chest, and any other indication of a liability to pulmonic disease.
8. Impaired or inadequate efficiency of one or both of the superior extremities on account of fractures, contraction of a joint, deformity, etc.
9. An unusual excurvature or incurvature of the spine.
10. Hernia.
11. A varicose state of the veins of the scrotum or spermatic cord (when large), sarcocele, hydrocele, fistulas.
12. Impaired or inadequate efficiency of one or both of the inferior extremities on account of varicose veins, fractures, malformation, permanent lameness, contraction, unequal length, etc., etc.
13. Ulcers, or unsound cicatrices of ulcers likely to break out afresh.

Educational Examination.

The following outline, problems, and questions are given as illustrating the nature and scope of the educational examinations. While these illustrate the character of the examination, it should be distinctly understood that different questions will be used at each examination. The examinations will be partly written and partly oral.

Arithmetic.

a. Fundamental rules, with methods of proof and reasons for processes.
b. Factoring: G. C. D. and L. C. M. and their applications; common and decimal fractions, their kinds, solution, and reduction from one to the other, with both the rule and the *reason* for each operation.
c. Denominate numbers; tables; reduction, ascending and descending; changing denominate numbers to equivalent decimals.
d. Ratio and proportion, their kinds, methods and applications.
e. Mensuration of lines, surfaces, and solids, and their representation by drawings.
f. Percentage and its applications.
g. Involution and evolution, and their applications.
h. Analysis of mental problems.

Illustrative Problems and Questions.

1. Write in figures one hundred and sixty billion three million seventy thousand and five. Write in words 246004050. Write in Roman numerals 40, 90, 144; and in Arabic numerals L, XIV, LIX, CVIII and DCCLXXV.
2. Add two and five-tenths, eighty-six thousands, twenty-four ten-millionths and 3-tenths, multiply the result by .0002, and divide the product thus obtained by .00004.
3. Find the cost of 20 acres, 3 roods and 30 perches of land at $62.50 per acre.
4. A man sold $24\frac{7}{8}$ bushels of wheat at $\$2\frac{3}{5}$ per bushel, and received in payment apples at $\$3\frac{3}{4}$ per barrel. How many barrels of apples did he receive?
5. Reduce 6 furlongs 20 rods to decimal of a mile.
6. Reduce .0256 to a common fraction and $\frac{3}{16}$ to a decimal.
7. Add $\frac{7}{8}$, $\frac{7}{10}$, $\frac{11}{12}$, $\frac{3}{4}$, and divide the result by $\frac{3}{5}$. Also reduce to its simplest form $\frac{6\frac{1}{2}+2\frac{2}{3}}{\frac{4}{7}}$.

8. Define fraction, common fraction, decimal fraction, proper fraction, mixed number, division, greatest common divisor, least common multiple, cancellation, long division, and denominator.

9. Find the prime factors of the following: 256, 312, 63, 280, 289 and 1386.

10. Divide the least common multiple of 240, 720 and 150 by the greatest common divisor of the same numbers.

11. Find the interest on $240 for 3 years and 6 months at 8%.

12. How must I sell cloth that cost $4 per yard so as to gain 20%?

13. A and B together have $540, and A has twice as much as B. How much has each?

14. $\frac{3}{4}$ of 24 is $\frac{2}{3}$ of what number?

15. What number divided by .024 will yield a quotient of .25? Prove.

16. Find the area and hypothenuse of a right-angled triangle whose base is 240 and altitude 75.

17. How many men would be required to cultivate a field of $2\frac{5}{8}$ acres in $5\frac{1}{2}$ days of 10 hours each, if each man completed 77 square yards in 9 hours?

18. If 5 cubic feet of gold weigh 98.20 times as much as a cubic foot of water, and 2 cubic feet of copper weigh 18 times as much as a cubic foot of water, how many cubic inches of copper will weigh as much as $\frac{7}{9}$ of a cubic inch of gold?

19. What is the effect of dividing the denominator of a fraction by a whole number, and why?

20. What is the effect of annexing a cipher to a decimal, and why?

21. If the same number be subtracted from both terms of an improper fraction, what will be the effect? Why?

22. Give the rule for reducing a common fraction to an equivalent decimal, and explain why the resulting decimal will be equal to the common fraction from which it is obtained.

23. Give the rule for dividing one decimal by another, and explain why the decimal point in the quotient is placed where the rule directs.

Grammar and its Applications in Conversation, in Letter-Writing, and in Composition.

Outline.

a. The parts of speech, with their properties and inflections.

b. Analysis of ordinary simple, complex and compound sentences, and the fundamental relations of subject, copula, predicate, object, etc.

c. Punctuation, capitalization, spelling, etc., in original composition or from dictation.

d. Corrections of improper use of words, constructions and sentences, in ordinary conversation, and in composition and letter-writing.

Illustrative Exercise in Grammar.

1. Name the parts of speech and define noun, adverb and conjunction.

2. Name the properties of the noun; of the verb.

3. Decline boy, he, it and who.

4. Conjugate the verb to throw in the indicative mood, past tense, passive voice.

5. Write the plural of lady, turkey, this, that, box, house, potato, mouse, sheep and father-in-law.

6. Name the relative pronouns and compare good, little, old, happy, big, thin and likely.

7. Parse all the words in the following sentence: The birds sing merrily in the green trees.

8. Correct the following and give reasons:

a. Him and me will come.

b. He saw John and I in the garden.

c. Who did she marry?
d. Between you and I there is but little difference.
e. I laid down and slept because I was to tired to set up.

9. Capitalize, punctuate and correct the following sentences:
a. the Groves were gods first temples
b. when will You and i get there
c. john left New york i cannot tell when he will git Home.
d. John, and me and James went to school. at Boston last winter. We got home on thursday.

10. Write a description of this room and its furniture. Be careful to capitalize and punctuate correctly.

Geography.

1. Give the distance in miles around the earth; also the length of its diameter. How wide is the Atlantic Ocean? How far would you have to travel in going across the United States from east to west? from north to south? When you do not know the exact answer, put down about what *you think* would be the correct answer.
2. Name the grand divisions in order of their size; of their population. Where do the most highly civilized nations live?
3. Bound Europe and name five of its principal rivers, telling where they rise and empty. Also name and locate five of the principal cities of Europe.
4. Name the principal mountain systems of Asia; of Africa; of South America.
5. Name the States of the United States that border on the Atlantic, and give the capital and metropolis of each. Also name the largest State of the United States; the smallest; the most populous.
6. Give the leading products of Georgia; of California; of Pennsylvania; of Illinois.
7. Locate the following and tell what they are: Sahara, Washington, Columbia, Portland, Blanc, Nile, and Mexico.
8. Bound the United States, and give its area and population.
9. Name the political divisions of South America.
10. Write fifteen lines about Africa.
11. Bound your native State, giving its capital, metropolis, and principal products.
12. How are United States Senators elected, and for how long a term?

United States History.

Outline.

a. Aborigines of America.
b. European settlements, when, where, and by whom.
c. Colonial history, and inter-colonial wars.
d. American Revolution, its remote and immediate causes and results.
e. Constitution, why and when adopted; its departments and powers.
f. The Presidents and events of their administrations.
g. War of 1812; Mexican War; Civil War.
h. Current events.

Illustrative Questions.

1. Tell something about Columbus, stating where and when he lived, what he discovered, what voyages he made, etc. What do you think of the treatment that he received?
2. Name the different European countries that tried to get possession in America, and tell which three were the most successful.
3. Give an account of the French and Indian War, telling what it was about and how it terminated.

4. Write thirty lines about the American Revolution, telling its cause, naming five principal battles, three generals on each side, etc.

5. What was the Declaration of Independence? Who wrote it?

6. Name the Presidents of the United States and give the leading events of Jackson's administration.

7. Tell something about Franklin, Wolfe, Morse, Fulton, Longfellow, Emerson, Arnold, and Alexander Hamilton.

8. What cities have been the capital of the United States?

9. What happened in 1492? 1565? 1607? 1620? 1776? 1876?

10. How long did the war of the Rebellion last, and during whose administration did it take place? State the provisions of the Fourteenth and Fifteenth Amendments.

11. What is the objectionable feature of Mormonism, and what measures have been advocated in Congress to eradicate this evil?

12. What event is there talk of celebrating by an International Exposition at Washington in 1889? In 1892?

13. What is the use of International Expositions?

NOTE.—It is suggested to candidates for admission to the Corps of Apprentices and Cadets that, before leaving their places of residence, they should cause themselves to be thoroughly examined by a physician, and by a teacher or instructor of good standing. By such examinations any serious physical disqualification or want of educational preparation would be revealed, and the candidate spared the expense and mortification of a useless journey and rejection. But it is to be understood that such examination is solely for the convenience and benefit of the candidates, and in no manner affects the decision of the Official Examiners of the Board.

Exhibit V.

BALTIMORE AND OHIO TECHNOLOGICAL SCHOOL.

CIRCULAR No. 1.

BALTIMORE, *October* 1, 1885.

In view of the necessity of postponing for the present the initiation of the Technological School program in its entirety, the present course of instruction will be conducted with special reference to its practical utility:

First. In advancing the entire force of apprentices within reach of its influence in their several mechanical pursuits; and

Second. In advancing the theoretical instruction, as far as may be practicable with the limited appropriation at command, of such apprentices as past examinations have shown possess sufficient common-school education to justify the hope that they can, without additional school-training in academic studies, qualify themselves for positions as officers in its service. So far as may be practicable, the work of the school shall have a direct bearing upon, and immediate connection with, the various duties in the shop with which the apprentices are or may be charged. To this end the technological and academic instruction will be carried on under separate instructors, each responsible for the conduct and success of his particular department, and each reporting to the undersigned, as representing the Board of Directors of the Technological School.

To Mr. C. W. Scribner, as a specialist in technology, and as senior instructor, is assigned charge of the practical instruction of apprentices in the shops and drawing-room. He will be at liberty to maintain such separate class-instructions in purely technical subjects as he deems necessary to promote the interests assigned him, and as will not interfere with the apprentices' shop and academic duties. In the performance of this duty he will spend not less than six hours per day in the shops, and not less than two additional hours in the drawing-room, and in such class-instructions as he may inaugurate, Sunday excepted.

His duties as technological instructor will consist:

First. In exercising a general supervision over apprentices in the shops and in applying their theoretical knowledge to their labors.

This duty will be performed in accordance with a plan to be agreed upon between the instructor and the several foremen: which plan must be of such character as will give the instructor proper facilities for overseeing and directing the labors of apprentices, so far as they are learners, and to question and counsel any boy or boys while at work, in order to determine their understanding of what they are doing, to make explanations and to direct their operations in such way as to enable the apprentices to gain comprehensive and practical knowledge of the scientific principles involved in what they may be doing.

In exercising this duty, the instructor will have no right or authority to antagonize or interfere with the orders of the foreman in charge, so far as they relate to the Company's work, nor to interfere with its proper performance; nor shall he, for the purpose of instruction or examination, unnecessarily, nor for any great length of time, even when necessary, retard the work which the apprentices are doing. To prevent confusion in the Company's work, it is to be understood that the foremen have the undisputed right to decide what work is to be done by apprentices and when it is to be done; the recommendations of the instructor in the matter of the assignment of apprentices shall be made first to the foremen, and shall be carried out by them unless they are clearly in conflict with the interests of the service. In each case where the instructor and foreman fail to agree, either in formulating the plan for the joint management of apprentices or upon the proper interpretation and scope of this arrangement, the question or dispute shall be referred to the Master Mechanic or Master Car Builder, to whom the foreman reports, and if he cannot satisfactorily adjust the difference, the whole matter will be referred to the General Manager for settlement.

The foregoing applies to all apprentices at Mt. Clare Shops.

Second. A certain number of hours per week, not fewer than three, shall, by agreement between the instructor and foremen of the various shops, be set aside, in which the technological instructor shall assemble the apprentices of the first class for the purpose of explaining the scientific principles that are involved in the work on which they are engaged, of suggesting and illustrating the most economical methods of work, of showing how different parts of machinery are put together, and of pointing out the office of each part. He shall explain why some other way of constructing or doing such work would not do just as well, and be as economical as the way he suggests. He shall point out difficulties that are yet to be overcome in the construction and operating of machinery, and, in short, make the instruction of such a character as to set apprentices to thinking and devising for themselves. He shall also give instruction on the nature of the materials, and in the use and care of tools and machinery.

In the performance of these duties he shall have authority to utilize the machinery in the shops where the same is not in use.

The technological instructor shall study the machinery and methods of work now in vogue in the shops, and shall make recommendations to the foreman or to the Master Mechanic or to the Master Car Builder, as the case may be, of any improvements in the method of work, in tools, in machinery, or anything that in his judgment will increase the efficiency of the shops.

He shall also study the shop-work with a view of recommending to the undersigned what academic subjects might be taught in the school, and the best methods of teaching them with a view of their immediate application in connection with the shop-instruction.

He is expected to study and make note of the capabilities and the aspirations of the various apprentices, and the joint recommendations of the instructor and the foreman to the General Manager, through the intermediate officers, as to the aptness, progress, skill and commendable traits of any apprentice, shall determine whether his apprenticeship shall continue for a longer or shorter period than the

usual time prescribed (four years); but no boy whose standing in the school-studies is habitually low shall have the time of his apprenticeship reduced to less than the usually required four years, however expert he may become in the shop.

The shop-instructor shall, during the academic year (being guided by his experience and observations in the shops), make a classification of the regular kinds or pieces of work which are constantly required to be done in the shops, and on which apprentices should have practice, and arrange them in the order in which it is best to have apprentices take them up in learning their trade, submitting the same to the Master Mechanic and Master Car Builder.

He shall also, during the academic year, outline methods of instruction and recommend the academic studies that, in his judgment, are most suitable for the apprentices of each trade, and for the students of civil and mechanical engineering, with a view to preparing a permanent program and prospectus for the succeeding year.

In all matters relating to the school he will report direct to the undersigned.

To Mr. Coler is assigned charge of all academic studies, which will for the present be confined to the several sections of first-class apprentices.

Under this arrangement he will spend not less than eight hours per day in the discharge of his duties. Of this time he may devote one or two hours daily to the shops, in order to observe the needs of apprentices, the work and equipment of the shops, so as to make the school-instruction both practical and interesting, by drawing his illustrations in teaching as far as possible from machinery and operations in the shops where the boys are daily employed.

The academic department shall include three sections of apprentices. The first grade shall consist of all those who are qualified to meet the requirements of General Order No. 5 for admission to the first class therein mentioned.

The second section shall consist of such apprentices now in the service as may, with a reasonable amount of teaching, be qualified for admission to the first section.

The third section shall consist of all other apprentices whose time of apprenticeship does not expire before January 1, 1887.

All apprentices who receive academic instruction (Sections 1 and 2) must take Drawing at least two hours each week. The technological teacher may also require apprentices who are not in these sections to take Drawing.

The subjects for academic instruction for the first class are Algebra, Geometry, and English and Elementary Science.

Apprentices who are preparing for admission to the first section are to be known as second-section students.

These shall take Arithmetic in addition to Drawing as required studies, and they shall choose a third subject from the following: History, Geography, English, Elementary Science, Steam and Steam Engine, and Mensuration.

Apprentices of the third section are required to take Drawing at least two hours per week. They may at any time enter either of the other preparatory sections, provided those sections are not already full, and provided they are qualified to profit by the instruction to be given in the class, which last is to be decided by Mr. Coler.

Students of the third section must attend the free city night schools nearest to their homes, and it shall be the duty of Mr. Coler to see that this requirement is fulfilled.

Each teacher shall make a weekly report of how much time he has spent in each shop and school-room, the character of teaching, results, etc.

Each to report directly to me, but to recommend jointly anything that relates to their two departments.

W. T. BARNARD, *Asst. to President.*

Exhibit W.

SCHOOL REPORTS.

January 30, 1887.*

DR. W. T. BARNARD, *Assistant to President.*

Dear Sir:—In compliance with your request for a special report, showing what has been accomplished by the Technological School from its inauguration to the present date, I respectfully submit the following:

From the Circular of January 15, 1885, setting forth the management and policy of the school, and from your subsequent instructions, we have understood the purpose of the school to be threefold:

1. To maintain an educational examination as a condition of admission to apprenticeship, and to afford such elementary technical instruction to all apprentices as would make of them intelligent journeymen; the apprentice instruction to be known as the Journeyman's course; this course to be free to all apprentices, and to serve as preparatory for the Cadet course for young men whose ability and character are good, but who need preparatory training.

2. To organize a class of Cadets for advanced technical instruction in such subjects as bear upon the departments of railway service in which they are to engage; the object of this course being to fit young men to become foremen and for other subordinate positions; this class to be composed of apprentices or other young men who shall pass a required examination and present testimonials of ability and character; a reasonable tuition to be charged for this course.

3. To secure to the service as Cadet officers a limited number of young men possessing superior ability and educational qualifications, to whom thorough and comprehensive technical instruction should be afforded, while at the same time these young men should get a comprehensive and practical knowledge of the various departments of railway service and the mutual relations of these departments; the object of this course being to fit the students for the highest positions of responsibility in the service.

It is with these ends in view that we have been guided in the management of the school, and our plans have all along contemplated an early organization of the Cadet Class. With reference to the Cadet Officers' Class, we have understood that it was your policy not to admit young men to that course of study until they shall have completed the Cadet course and thus have demonstrated whether it will be profitable to the company to continue instruction to them. We have not, therefore, undertaken, except in a general way, to forecast the subjects of study and the management of that class.

That there are substantial reasons for the apparently slow progress we have made, and that we have nevertheless worked out results and gained experience that will be far-reaching in their economic value and otherwise beneficial consequences, providing it is thought best to continue the school, will appear from considerations and facts to be set forth in detail in what follows.

In February, 1885, one hundred and forty-seven apprentices, then in the service at Mt. Clare, were examined by Mr. Scribner and myself, and in July and August of the same year Mr. Scribner and Mr. Sullivan examined about three hundred and fifty apprentices in the shops along the line. The results of these examinations went to show that not one of the five hundred boys and young men in the various repair and construction shops was sufficiently advanced to pursue technical studies with profit to the Company and to himself. We were greatly surprised that among so many boys there should be found such uniform deficiency in the most elementary school-studies. Combined with this lack of elementary knowledge was a corresponding lack of inclination on the

* Although my report is dated October, 1886, the last sections were unavoidably delayed, so that school reports of this date are inserted. W. T. B.

part of these apprentices to make of themselves anything more than ordinary routine and rule-of-thumb mechanics. It must be evident that such apprentices will require constant supervision in even the simplest details of their trades, and that when they become journeymen they will be untrustworthy and unprogressive.

Thinking that perhaps a few of the most promising boys might, by receiving preliminary training in night-classes for six months or a year, be prepared for the more elementary technical studies, we determined to give them instruction in the rudiments of grammar-school branches. Having secured an order from the General Manager to this effect, we required about forty boys to attend night-classes from the first of March to the twentieth of June, 1885. This was done with the hope that all might profit to a certain extent by the elementary instruction thus afforded, and that from these forty boys there might be a dozen or more who would work their way up so as to profit by the technical course we had in view for apprentices; but a short experience convinced us that for the most of these boys the attempt was made in vain. Some would if they could; others could if they would. Only three out of these forty apprentices have made commendable progress in all the school-studies, though none of them are any the less valuable to the service for having been required to attend the classes, and several have done well in drawing in spite of their deficiencies in academic studies.

It would be wrong to attribute the failure of these boys to advance in theoretical studies wholly to their inability or unwillingness to profit by the class-instruction that was offered them. It should be remembered that in addition to their not having previously formed habits of study—a fault of their parents and former teachers—these boys came from daily associations in the shops, the very atmosphere of which was discouraging to efforts for mental improvement; for the idea that a workman should pursue school-studies has almost invariably been ridiculed in the shops,—and ridicule is apt to dampen the ardor of students who have not advanced far enough in studies and experience to appreciate the importance of education. Moreover, the work of instructing apprentices was new to the teachers, and we made some mistakes, one of which was an attempt to put all boys through precisely the same kind of training without regard to individual aptitudes. I think, too, that the work at first attempted was too severely mathematical for apprentice studies. Dry, abstract mathematical drill will not interest apprentice boys, nor make intelligent, thinking mechanics of them. With the exception of drawing, we did not succeed in giving the instruction enough of a tangible and practical bias to encourage boys to take an interest in our classes.

From my own experience and study of the subject since my connection with this school, and from the testimony of teachers and employers in Europe who have made similar attempts, I am convinced that while it is possible and desirable to educate apprentices in technical subjects during apprenticeship, even though the instruction be wholly confined to night-classes, it is equally certain that to try to educate boys who have not formed habits of study before entering upon apprenticeship is a useless waste of time, patience and money. Although there may be exceptions, the results are usually very meagre and unsatisfactory.

Since March, 1885, there have been, in accordance with your plans and instructions, regular educational examinations every month, except July, 1886, of applicants for apprenticeship; and, with two or three exceptions, no boys have been admitted to apprenticeship at Mt. Clare without first trying this examination. At first we had to make the standard of requirements very low, in order to get enough boys to supply the demand for apprentices; but there has been a gradual, though decided, elevation of that standard, so that at the present time none can be admitted without a fair knowledge of the rudiments of elementary English branches; nor then without demonstrating some ability to think, and expressing a willingness to avail of the school-instruction by regular and prompt attendance at the classes if admitted to apprenticeship.

As the result of these examinations, we had, when the school year began in

October, 1885, about thirty apprentices capable of pursuing more advanced studies. Guided somewhat by our experience the preceding term, and profiting by observations that I had made in the management of workingmen's and apprentice schools in Europe, we made some decided changes in the subjects and methods of instruction. Classes were formed in drawing, in mathematics, in the study of the locomotive engine, and in physics. Instruction was also given in English and in history, and a few classes were still sustained for the elementary instruction of the forty boys who had been in the school the previous term. These classes, with some changes and additions, were sustained during the school year ending in June, 1886, and about eighty different boys, more or less advanced, received instruction during that year, all of whom were required to take drawing and to choose at least two academic studies. In addition to the general class-instruction, boys were encouraged to read many books on general and technical subjects, and a few of them were induced to take an interest in the scientific and mechanical journals which come regularly to our library. We also had a number of science lectures illustrated by simple experiments. These exercises proved both interesting and instructive to the boys.

For a more complete and detailed statement of the academic work undertaken, and which with some modifications was carried out in the school year ending June 1, 1886, I respectfully refer you to my report of October 9, 1885, a copy of which I hand you herewith.* But the work accomplished by the school for that year was by no means confined to academic studies and class-instruction.

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*MT. CLARE, *October* 9, 1885.

DR. W. T. BARNARD, *Assistant to President.*

Dear Sir:—The following is the course of academic study which I have marked out for the present school year. It contemplates two terms—one to end February 1, and the other at the close of the school year. I have arranged the course with reference to the three classes of apprentices indicated in your school circular of October 1 (Exhibit V):

1. Those in the First Section of the regular technical course—First Term: Algebra, Physics, Steam, the Locomotive Engine, and Drawing. Second Term: Practical Geometry, Physics, English, and Drawing.

2. Those who are not now prepared for the First Section, but may be so prepared with a reasonable amount of teaching and encouragement.†

First Term: (1) All required to take Drawing one night each week. (2) Each boy required to choose two studies from the following: Arithmetic, History and Geography, Elementary Physics, Steam, the Locomotive Engine, and English.

Second Term: About the same as First.

3. Apprentices who were not likely to be able to prepare for advanced studies. These were to be required to take Drawing one or two nights each week at Mt. Clare, and to attend the city night-schools.†

In justification of our attempt to introduce technical studies with so little preliminary preparation on the part of students, I would call attention to the following considerations:

1. That in English schools boys with no better elementary education than many of our boys possess, study these subjects in night-schools after working all day, and some of them pass the Government's examinations in science, and the City and Guilds of London examination in technology, with honor.

2. These studies will produce just as good, if not better, educational results, and have more practical value, than the study of the ordinary elementary school-branches.

3. The study of elementary science experimentally illustrated, as we intend it shall be, will do much toward awakening an interest in, and showing the utility of, more abstract studies, and the boys will learn more mathematics with the science studies then they will without them. The science studies will also go far toward creating an interest in the scientific and mechanical books and papers that are in our library, and prepare the boys to profit by such reading.

At first thought, it may not seem so desirable to have science taught to apprentices as drawing. The drawing produces visible results and its value is therefore much more readily appreciated. But if we had some graphic method of representing the results of science-teaching—the habits of thought, observation, intelligent inquiry, and definite expression that are thus developed—I believe the vote of those concerned would be to continue the science-teaching along with the instruction in drawing.

† It was found later that this was impracticable. As before stated, experience soon showed that it was useless to waste time on boys who had not previously formed some habits of study, and so many boys were coming into the service under the provision of the educational examination that it was decided to devote all the time and resources of the school to their advancement. G. P. C.

It has been our constant endeavor to carry the instruction beyond the school-room into the shops after the manner set forth in your school circular of October 1, 1885. [Exhibit V.] Owing to difficulties which are obvious and inherent to such an undertaking, our progress in this direction has been slow. Something has been done, however, in the way of supervision and systematic instruction of apprentices in the shops, and our experience in this direction I regard as invaluable, so far as it has gone.

Investigations in the shops by conversations and observation have developed the fact that many boys and young men had completed or almost completed their apprenticeship in the machine-shops without being able to tell the difference between cast and wrought iron, without knowing whether steel is a native or manufactured product, and equally ignorant of many other simple though important and significant facts which are intimately related to their trades.

In the performance of his specified duties as shop-instructor, Mr. Scribner made a study of the various trades, machines and processes in the shops, and of the successive steps in apprenticeship, with a view to recommending a course of shop instruction that should be parallel to the theoretical studies taught in the school. By short, pointed conversations with the boys while at their machines, which did not at all interfere with the work they were doing, the shop-instructor was enabled to set boys to thinking intelligently about the machines and the work upon which they were engaged. In this way the class-room instruction could often be immediately applied, and apprentices were directed to books and mechanical journals where they could get still further knowledge.

Mr. Scribner also took groups of boys from machine to machine and from shop to shop for the purpose of studying machinery and mechanical processes in detail and in their relation to each other. Attention was called to the uses of the machines and the scientific principles involved in their construction and operation, and one class of advanced boys were thus permitted to supplement their class-room study of the locomotive engine by seeing its parts and the successive steps of its construction.*

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4. It cannot reasonably be expected that the progress in study by apprentices who work all day in the shops will be anything like as perceptible and efficient as is the progress of young men in such schools as the Massachusetts Institute of Technology, where only a few hours each week are devoted to shop-work. But by choosing such science studies as have the most direct bearing upon the work in the shops, and pushing these studies, some progress can be made. While we will not give as much *theory* as is given in other schools, we will give much more *practice*, and our present system of shop-instruction contemplates an immediate application of theory, whereas much of the theory in other schools is never applied. I believe that, so far as the interests of the employer are concerned, more good will result from a technical school in which *practice* predominates over theory, than in one where the reverse is true. A school as such looks for the highest good in each boy, and this is right; but in such a school as we are seeking to build up, the problem is how to make the instruction of such a character as to justify the employer in maintaining the school. This, I believe, can be done by carrying the instruction not merely up to the shops, but *directly into them*. Yours truly,

G. P. COLER,
Instructor in English and History.

*(The following extracts from reports of Mr. Scribner, who was principal of the school till June, 1886, will afford a general idea of the work that was attempted in the way of shop-instruction.—W. T. B.)

MT. CLARE, *November* 28, 1885.

DR. W. T. BARNARD, *Assistant to President.*

Dear Sir:—My time at Mt. Clare has been taken up much as during the week previous, a rather large share being still required for Drawing, as will be the case until we are well started. We organized an advanced class of those who have had Drawing before coming here, selected from our Wednesday and Tuesday afternoon classes. These are to take up Descriptive Geometry, and will meet for the present on Friday afternoon at 3 o'clock. Every member of the school, some seventy-five in all, is now having one lesson weekly in Mechanical Drawing, the First Section meeting for three hours in the afternoon, and the other sections for two hours, at night only. The progress this week has been even more satisfactory than last week, and as soon as we get our instruments and some other necessary equipments, the Department of Drawing will be fairly on its feet. In the shop I

It seems to me that judicious and systematic shop-instruction will do more toward bringing about visible economic results than any other feature of the school. I am firmly convinced that it is possible to arrange parallel courses of

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continued the instruction on the locomotive, taking another set of boys, and expect to be able to do still more of this work next week.

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Besides the shop-instruction I have during the past week turned my attention especially to that part of our present program [Exhibit V] which refers to studying "the capabilities and aspirations of the various apprentices," beginning with those who constitute our First Section. I spent some time in talking with each personally, and find that by calling their attention to the real purpose of their coming here, and the means they must use for their own advancement, it is always possible to arouse greater interest in their shop-work and their studies. Another result of such questioning is to point out the need of instruction in special subjects which are very important.

As an example of this, I found that some very intelligent apprentices had no very clear idea of the difference between *wrought* and *cast iron*—a knowledge which is essential to progress and efficiency in shop-work. Of course, even with no instruction whatever, they could not remain in the shops very long without getting some notion of this difference, and in certain very practical directions a far better idea, perhaps, than any one has who has never worked in a machine-shop. Yet it is manifest that clearer and truer notions on such subjects than can be picked up in the shop are needed, even at the outset, and will prove invaluable to them as they go on in their work.

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Another point which I have taken up this week is referred to in our program in these words: "The shop-instructors shall make a classification of the regular kinds or pieces of work which are constantly required in the shop," etc. Here I have commenced where our apprentices begin, at present.

The regular arrangement has been to have them spend a long time at first in turning out the *bolts* used in various parts of the locomotive and elsewhere. I have obtained from the Drawing-room special information about the kind and number of these bolts—some 700 in the ordinary locomotive—and upon the necessary work which these bolts require, in the machine-shop, I propose to formulate such a course of instruction as will make the work at the "bolt-lathes," which some boys now find tediously long, a source of interest and usefulness by giving them distinct ideas about the uses of these bolts, the sort of finish they require, and the quickest and best ways of making them. This will be, it is true, an experiment, but a little study shows it quite possible; for the great variety of uses for these bolts calls for different degrees in the nicety of fit and finish to be given them, and this should exercise the boys as to the time each should have, although at first this cannot, of course, be left wholly to them. And then, if their attention is called to it, the very variety referred to is itself of value, illustrating the many uses of "the bolt." So, too, with other parts of our program that have special bearing on the work of this particular shop, practical methods of work can be outlined. Meanwhile, I need not neglect the other shops, though for particular attention they will have to wait their own turn.

Very respectfully submitted,

C. W. SCRIBNER, *Principal.*

MT. CLARE, *December* 19, 1885.

DR. W. T. BARNARD, *Assistant to President.*

Dear Sir:—With reference to organization of shop-work, I have, during the hours not spent in individual instruction, been working on three different lines: (1) In arranging pieces of work made into a shop-course; (2) In arranging a definite agreement with foremen; (3) In determining the way in which instruction in the use of tools can best be given in our shops.

On the latter point I find that much time is used to small purpose if I talk to apprentices separately on this subject, instead of to classes. I have, therefore, decided that, while I can continue this to some extent, my best plan will be to teach in small classes wherever possible; this plan also making the use of a fixed system much easier. To this end the two points first named relate. And (1) the cataloguing of standard shop-pieces has been continued, and I purpose to have sketches of them arranged in a book, noting on the page opposite the name and use to be made of each piece, the machine-tools to be used in fitting it up, the various cuts to be made and the cutting-tools to be used with each machine-tool. This done, they can be classified into several parallel progressive courses; and though all this consumes time, it will in the end save far more by securing a working system so arranged as to give better instruction, to several boys at a time—unquestionably a better plan than to give individual instruction only. But all this would avail little, if each piece used as an exercise had to be done *only* under orders from the foremen, to be rushed through when time could be ill afforded for requiring the boy's attention to the form of his cutting-tool, and for explaining the reason why each part should be shaped as it is, or perhaps at a time when the instructor could not be present; in either case merely verbal directions and no working drawings being furnished. But while convinced that to work in this way I must have sole control of certain machines at certain hours, and of the work to be done on the "instruction-pieces," I was not first to suggest it, as I had to be sure that such a plan would not delay the work; and while one clause of our shop program gives the instructor the use of idle machinery, another states that "the

instruction for the school and for the shops of such a character that the shop-work will create and intensify interest in the school-work and *vice versa*.

In the management of the Mt. Clare school we have endeavored to get boys interested in reading the history and development, and in knowing something of the present status, of their several trades and industries. It is reasonable to expect the workers of iron and steel to have some knowledge of the history of the iron and steel industries; that electricians should know the past, present, and prospective future of electricity; also, that engineers should know about the history of the steam engine and the various steps in the invention and improvement of it. This method of special historical study and investigation of industrial subjects will serve the two-fold purpose of promoting intelligence and stimulating and directing invention. The workman who has inventive genius will be much more likely to develop it and to avoid wasting his time on what has been already worked out, if he knows what has been done in past ages in the field of his specialty.

One of our great difficulties is to find books that will furnish both interesting and profitable technical reading for boys who are to become railway mechanics or operatives. A literature for apprentices needs to be written. Another hindrance to our work is the absence of text-books bearing on railway industries. The efficiency of any industrial school is dependent upon the adaptation of text-books to the purpose for which the school was established. Our teachers have had to work up new subjects for class-instruction, and they often feel the need of text-books on these subjects. If such schools become common, suitable text-books will no doubt be forthcoming from enterprising publishers.

Instruction for apprentices must at first deal with things immediately around them and proceed from these to things more remote and general. I am quite certain that the way to success in such a school as we want to establish at Mt. Clare for regular apprentices, and even for Cadets, lies not so much in the class-room drills, valuable as these may be made, as it does in each teacher's ascertaining the special aptitudes and inclinations of the different boys, and then, when that aptitude runs in the direction of the teacher's specialty, in its being developed to the highest possibilities by class-instruction, by a judicious course of reading, by shop practice and instruction, and by personal influence in conversations and otherwise, of the teachers upon the students.

With reference to what the school is accomplishing this year, I am glad that I can report satisfactory results, considering the disadvantages under which we are compelled to work. As the result of the educational examination and the inducements which the Technological School offers to aspiring boys and young men, we now have at Mt. Clare, in the shops and enrolled in the school, about seventy apprentices whose ability is good and whose early education has not been wholly neglected. Instruction is given in Drawing, Descriptive Geometry, Physics, Mechanics, Algebra, and Geometry. There is a strong demand for classes in

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foremen shall have undisputed right to say what work shall be done by the apprentices and when it shall be done," and that the instructor's recommendations in such matters shall be made first to them. I am glad to say, therefore, that such recommendations as I have made have been followed, not as yet by the foreman's enforcing them, but by his suggesting, himself, that it would be much better and simpler to detail certain machinery at certain hours for instruction-purposes, fully assenting to the value of a fixed course of teaching when done in this way on selected pieces to which time could be given. I then proposed this plan to the Master Mechanic, who not only at once assented, but said he felt sure that this method would give the best results, and was in fact the only one to follow. And now, since this proposition has come from the shop, I can feel sure that it is the most practicable for us, and the most practical, too, at least in the sense of giving satisfaction to all.

I referred above to the fact that the boys used no drawings. I now intend that all this special work shall be done from drawings exclusively, and later on the boys can work from drawings which they have themselves made in the school—not, of course, their designs, but made by them from measurements of the finished piece and approved by the head draughtsman of our works. Thus all boys so trained will be able to do all their work from standard shop-drawings, whenever such a system shall be brought into more general use in our shops than is at present the case.

Very respectfully submitted,

C. W. SCRIBNER, *Principal.*

[illegible]

The fact that even if ability will enter the shops to get a trade and go to school at the same time, and that they can and will, under circumstances as discouraging as those resulting from our limited facilities for instruction and from the requirements of piece-work in the shops, prove the desirability and the economic value of school-instruction in connection with workshops.

This progress in school-studies was as all possible under such circumstances as it is assumed in the superior ability and trustworthiness of the apprentices that have been entered the shops.

Many of these young men are now able to do a journeyman's work and to increase the efficiency of the shops in numerous ways by their intelligence and enthusiasm in their work. They are willing to accept apprentice wages for their services in order that they may advantage by our class-instruction. But I very much doubt whether we can hold the best of these young men unless they are afforded more instruction than they now have. Some of them are talking of going elsewhere to enter school, and I cannot blame them for their desire to keep with our present school facilities.

Of the young men who have become apprentices since the inauguration of the school, our records show that the number who have been at least two years in their several institutions are as follows: Baltimore City College, 3; other high schools, 7; McDonogh School, 2; University of Alabama, 1; St. John's College, 1; Johns Hopkins University, 1 (one year only); Naval Academy, 1; St. Louis Manual Training School, 1. Three boys have come from the Baltimore Manual Training School. A number of other boys have attended academies or good grammar schools, and not a few have come from the country. Although the previous school advantages of these country boys have not been very great, they are nevertheless among the most faithful and earnest workers in the Mt. Clare school and shops, and are making good headway in their school and shops.

We have constantly endeavored to do the most that could be done, with our limited facilities, toward advancing the individual interests of boys who have come here for the purpose of obtaining an education while learning their trades. But we have not lost sight of the fact that in a school of this character, maintained by a corporation in connection with its shops, the highest good should be looked for in the furtherance of the material interests of those whose money goes to pay for the instruction. Our efforts to make the instruction practical and, as far as possible, of immediate usefulness to the Company, have already been recognized and appreciated by some of the heads of departments. We have been asked to recommend young men for positions requiring intelligence

and skill, and the demand for young men specifically qualified for certain positions is now greater than we can supply.

The educational requirements for apprenticeship have greatly improved the character and ability of apprentices at Mt. Clare. That industrial corporations should recognize the value of common-school training to such an extent as to make educational qualifications a condition of admission to their shops for the purpose of learning a trade, is an important movement in both education and industry. I would recommend that the monthly educational examination be extended, under the management of the school, to shops along the entire line. This can be done by sending the questions each month to the managers of the various shops, who should see that they are submitted to applicants for apprenticeship. The papers could then be sent to Mt. Clare to be looked over, graded, and returned to the proper authorities. The standard would of course have to be very low at first, but it could be elevated from month to month. The expense in this matter would be insignificant compared with the important economic results that could thus be attained.

In conclusion I will briefly summarize what has been accomplished by the school and its management since it was inaugurated:

1. The examination of 147 apprentices at Mt. Clare, and of 350 apprentices along the line, who were in the service when the school began.

2. The maintenance since March, 1885, of an educational examination as a condition of admission to apprenticeship at Mt. Clare.

3. The instruction in drawing and in elementary subjects of about forty apprentices who had been received into the service before the inauguration of the school.

4. The admission to apprenticeship of more than 100 boys, many of whom had already laid the foundation for technical training. Some of these young men do the work of journeymen, for which they are willing to receive very low wages on account of the school-instruction.

5. For more than a year we have been giving these young men the very best technical training in drawing, descriptive geometry, physics, mechanics and the locomotive engine, besides in the more general subjects of algebra, geometry, history, English, etc.

6. Our teachers, in their endeavors to make their instruction practical, have gone into the shops to study the machines, trades and manipulative processes, and to become acquainted with the boys while engaged in the performance of shop-duties.

7. Shop-instruction and supervision on a practical and systematic basis has been attempted, and to a certain extent carried out. The experience thus gained will be invaluable in future.

8. A number of problems, drawings, etc., have been prepared by our teachers from data gathered in and about the shops, and the use of these enables the instructors to make the instruction much more interesting and profitable than it would have been had the instructors relied solely on the use of text-books.

9. The nucleus of a physical laboratory for class-instruction and experiments by students has been formed.

10. A classification of the various steps of apprenticeship has been attempted, and some headway has been made toward that end, with a view to correcting errors in existing methods of apprentice-work and adapting the school-instruction to the wants of the shop. Efforts have also been made toward working out systematic plans of shop-instruction for educational results.

11. An important and extensive collection of scientific and mechanical books and magazines has been carefully made for the library.

12. Apprentices have, through the school, been brought into intimate relations with the library, and have thus been induced to do a considerable amount of useful reading.

13. Although we have not yet succeeded in putting the Cadet classes into operation, much prejudice has been overcome, and many who at first did not

believe in such a school have been led to see that school-instruction as supplementary to apprenticeship is both possible and desirable.

14. The knowledge of the maintenance of such a school by the Baltimore and Ohio Company has spread through the community and the country at large, and has given the company credit for manifesting a tangible interest in the welfare of its employes, and for thus adopting efficient and practical measures toward the effectual solution of labor problems.

Already other railway companies have indicated their intention to adopt certain features of our school-work in their shops.

15. Finally, the managers and teachers of the school have gained much practical experience that will be of great service in the future management of the school. The way has been prepared for the organization of the Cadet classes, and young men are ready to enter upon advanced courses of study as soon as these classes can be organized.

Very truly yours,
G. P. COLER, *Principal.*

DEPARTMENT OF DRAWING.

G. P. COLER, *Principal.*

Dear Sir :— When the instruction of apprentices in drawing first began, but little could be accomplished, owing to two causes: 1st. The character of the students; 2d. Lack of facilities. With only a few exceptions the students then in the school were those who had been for some time in the service, who had entered simply for work, and not with any idea or desire for "schooling," and who had been conditionally admitted to the school on an entrance grade far below the regular passing-mark. Their *capacity* for instruction was so limited as to render any attempts at it very discouraging. No drawing instruments were obtained for some time, and consequently no mechanical drawing was done at first, and the instruction consisted entirely of free-hand drawing.

Since then the condition of affairs has changed very much for the better. Drawing instruments were purchased and other facilities provided. The work in free-hand drawing is now equipped with a set of Prang's Drawing Models, a partial set of compressed paper "modèles en relief," and a few other models made at the school. The work in projective drawing is illustrated by a set of models showing the intersections of various geometrical solids by planes or by other solids. The most of these last-mentioned models were made by myself, and the list is rapidly being increased. The work in machine drawing is aided by a set of Thorne's working drawings which illustrate the best methods of practice.

The grade of the entrance examinations is now more rigid, and the larger part of the old students have either left the school, completed their apprenticeship, or have been dropped from school-work for incapacity. Raising the grade of the school-work is having a very noticeable result in the corresponding improvement in the character of the apprentices now in the service. Of those who have entered the service since the organization of the school, the majority are young men who would never have entered as apprentices except for the school, and it has come to my personal knowledge that some of the best of them are only continuing in the service in the hopes of the speedy enlargement of the facilities of the school. There are some cases of students showing an aptitude for drawing amounting almost to genius, and who already do work which, on the score of *neatness*, will compare favorably with that of the majority of professional draughtsmen, and who only need additional training in the technicalities of draughting to make them proficient draughtsmen, and valuable material from which the company may recruit for their drawing-rooms. One of the apprentices has already been advanced from the machine-shop to the draughting department, and only recently we had occasion to recommend another apprentice in answer to a call for another student for the same purpose.

On February 1, 1886, there were 78 students in the drawing classes of the school. Of these, 30 are still in the school. The remaining 48 have either left for cause, or have been dropped from school-work because they showed an incapacity or unwillingness to learn that made it impolitic to waste further energies on them. There are at present 58 students in the various drawing classes. The number is steadily increasing, the additions being invariably of a much higher grade than any of the apprentices were at the formation of the school.

The course in drawing now consists of a first-year class in geometrical drawing, a second-year class in projective drawing, a third-year class in machine drawing, a class in free-hand drawing, and a class in descriptive geometry. The instruction is almost entirely "individual" instruction rather than "class" instruction—this plan rendering it possible for each student to progress as fast as his ability warrants, and allowing his work to be slightly varied as his future requirements may demand. The drawings sent to you not long ago are a fair exponent of the system of drawing at present followed in the school. As soon as a proposed sectional model of a steam engine can be obtained, the instruction in machine drawing will be amended to include the making of working drawings direct from the models. The class in machine drawing is now engaged on the subject of spur gearing, and this will be followed by work in bevel and worm gearing. It is intended ultimately to give a systematic course in machine design.

Very respectfully,

WALTER L. WEBB,

December 31, 1886. *Instructor in Drawing.*

DEPARTMENT OF MECHANICS AND PHYSICS.

G. P. COLER, *Principal.*

Dear Sir:—Instruction in science was not begun until the school had been in operation for some time. A class in physics was first formed, and this year one in mechanics was organized. In addition to this regular work, occasional lectures have been given to other classes or to the whole school. My connection with the school began February last. There have been under my charge about seventy apprentices, in classes ranging from twelve to thirty members.

The aim has been to impart a knowledge of some of the elementary and fundamental principles and laws of the subjects considered, to illustrate them by experiment, to direct attention to their important applications, and especially to awaken an interest in this kind of study and cultivate habits of thoughtfulness and a desire for an intelligent understanding of the things which fall immediately to the notice of the student, such as the principles involved in the machinery he uses. It has been borne in mind also that these subjects are the necessary foundation for subsequent study of mechanism, the steam engine and other advanced and technical subjects, and especial attention has therefore been given to those topics which are of most importance as preparation for such subjects.

The method of instruction has been rather an experimental presentation of the subjects at hand, together with questions and class discussion, than ordinary text-book recitation. The boys have naturally shown a particular liking for experiments, and this has been encouraged by the introduction of such experiments as have been practicable. They are not made mere shows, but are presented in such a way as to demand careful consideration of the methods employed and the results obtained. The class in mechanics, for example, arrives at principles and laws as the result of experiment; these are then applied to the solution of problems, many of which are to be determined both by the law and as the result of special experiment. Among the latter may be mentioned the determination of the pressures of variously loaded beams upon their supports, and of the tension on the tie-rod of a crane of given form when supporting a known weight. A considerable part of this work is performed by the boys

themselves. This, besides giving clear understanding and increased interest, serves to make a direct connection between actual and theoretical work; it shows the way in which theoretical study may benefit the practical workman, and also leads to habits of considering and methods of dealing with real and practical problems at first hand.

Several causes have tended to make the results less satisfactory than they might otherwise have been. Many of the boys have had no previous study or training in this kind of work and are prepared only for what is most elementary; the classes have not been well graded, and that which is too advanced for some is already very familiar to others; the attendance has been made irregular and the time for study, which is meagre at best, has been seriously interfered with by night-work in the shops; there has been almost no apparatus except that constructed with limited facilities by the instructor. One of the most valuable results, however, is the change in the attitude of the boys as a class toward study and school-work. At first it seemed that the boys attended their classes simply because they were compelled to do so; they manifested little desire for anything better than not to go to school. It was then a difficult matter to even hold the attention of a class. During last year there was marked improvement in scholarship and interest, which was, I think, furthered by occasional visits to the shops and short talks with the boys concerning their school and shop-work. This year opened with fresh earnestness and spirit. The improvement made by those attending last year, and the superior class of apprentices who have recently entered the service many of whom have done so especially to avail of combined shop and school advantages, render the instruction much more satisfactory, both as regards the grade of the work and the spirit with which it is done.

The marked change which the school has undergone during the past year is, in my estimation, a matter of congratulation and gratifying surprise. The influence of the school in raising the character and general intelligence of the apprentices, their ambition to improve, and their increased earnestness, cannot but lead to most satisfactory results in their value and efficiency as workmen.

Very respectfully,

CHAS. F. SCOTT,

December 31, 1886. *Instructor in Mechanics and Physics.*

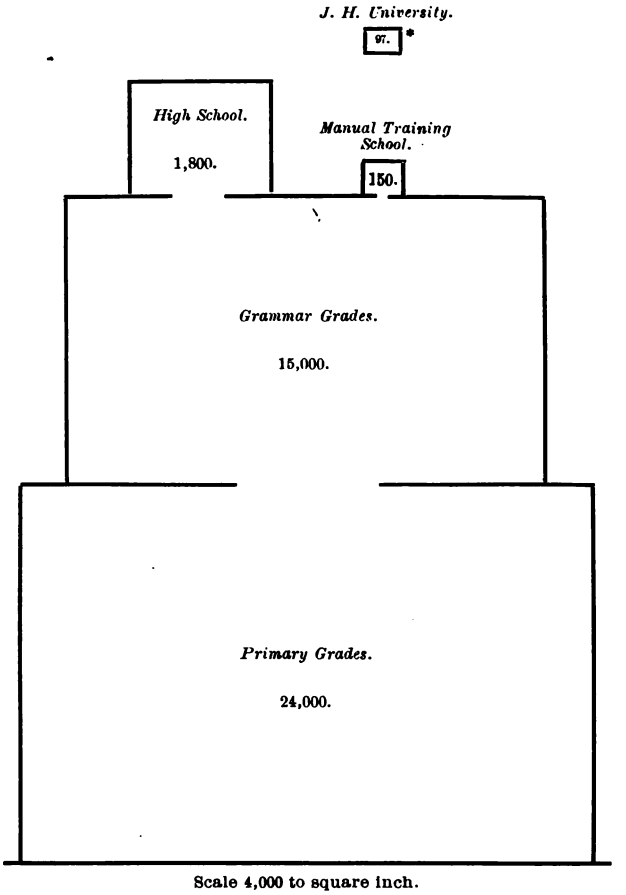
Exhibit X.

This exhibit contains a graphical representation (pp. 68–9) of Baltimore's school system as it is and as it should be. It will be seen by the first diagram that the provision for industrial training is practically nothing, and that there is no connection between our school system and the university. But little more than one-half of the children who enter the primary grades ever pass into the grammar grade. Some of the others enter private schools, but very many of them quit school to reinforce the ignorant, the vicious, and the criminal classes. One reason of this is that their parents do not see much in the grammar-school course that will be of use to children who have to make their living by manual labor. In addition to the subjects that are now taught in the grammar grades, there ought to be practical instruction in industrial drawing, experimental science, and physiology and hygiene. Instruction should also be given in the grammar grade to girls in cooking and sewing, and to boys in the use and care of tools. With such additions to the grammar-school studies, more boys and girls would be induced to complete that course, and thus be fitted for high-school studies. Those who from inclination or force of circumstances left school after completing the grammar-school course, would enter upon their life-work with a fair amount of elementary education and with habits of study sufficiently well fixed to make self-improvement possible.

BALTIMORE SCHOOL SYSTEM.

Diagrams representing by areas the attendance as it is and as it should be.

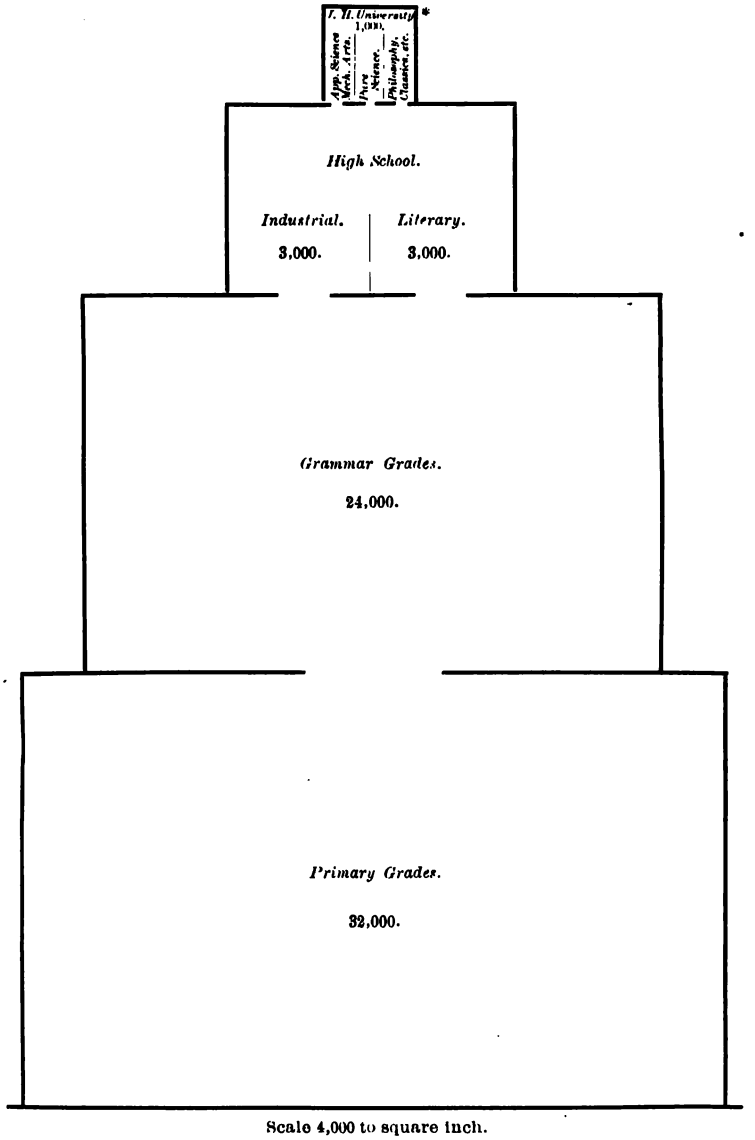
AS IT IS.



Scale 4,000 to square inch.

*The diagrams show the University in its relation to the city school system, without regard to other sources from which students are drawn.

AS IT SHOULD BE.



Scale 4,000 to square inch.

*See footnote, p. 68.

The grammar school should fit boys and girls for either a literary or an industrial high-school course, and for such art schools as the Maryland Institute.

The literary high school fits young people for commercial pursuits, for law, medical, or theological studies, and for college courses. It is certainly only fair that the school system should make equal provision for the preparatory training of those who are to become mechanics, architects, engineers, etc., and thus fit them for the higher training that is afforded in purely technical schools. The literary high schools of Baltimore cost $75,000 a year, while only $12,000 a year is allowed for industrial training in the Manual Training School.

The literary high-school course should continue as it is, with some slight modifications. An industrial high school should be provided for on a scale as large as the literary high school now is. The course of study should include manual training, industrial drawing, applied science, mechanic arts, bookkeeping, and history, government, etc., together with some literary studies. There ought to be a close connection between the literary and industrial high schools, so that students could change readily from one to the other. Some of the classes might be in common with mutual advantage.

The Johns Hopkins University should be considered as a part of the Baltimore school system, and its crowning glory. To maintain this position it should afford instruction in applied as well as in pure science.

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